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30 November 1977

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PHYSICAL SCIENCES AND TECHNOLOGY

No. 24

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DESCRIPTION OF SVETLANA ASSOCIATION, MANUFACTURER OF INTEGRATED CIRCUITS AND MICROCALCULATORS

Moscow EKONOMICHESKAYA GAZETA in Russian No 25, Jun 77 (insert pp 5-8)

[Five articles from the insert]

[Text] The organizing of the scientific and production complexes in the "Svetlana" association has made it possible to move on to through planning of scientific research and experimental design work, with due consideration for the continuity of the "research -- development -- production" cycle. The effectiveness of this approach is increasing through the wide application of network planning and control methods. The network flow-charts which can be processed on computers are drawn up taking the timewise coincidence of the individual stages of the "research -- production" cycle into account.

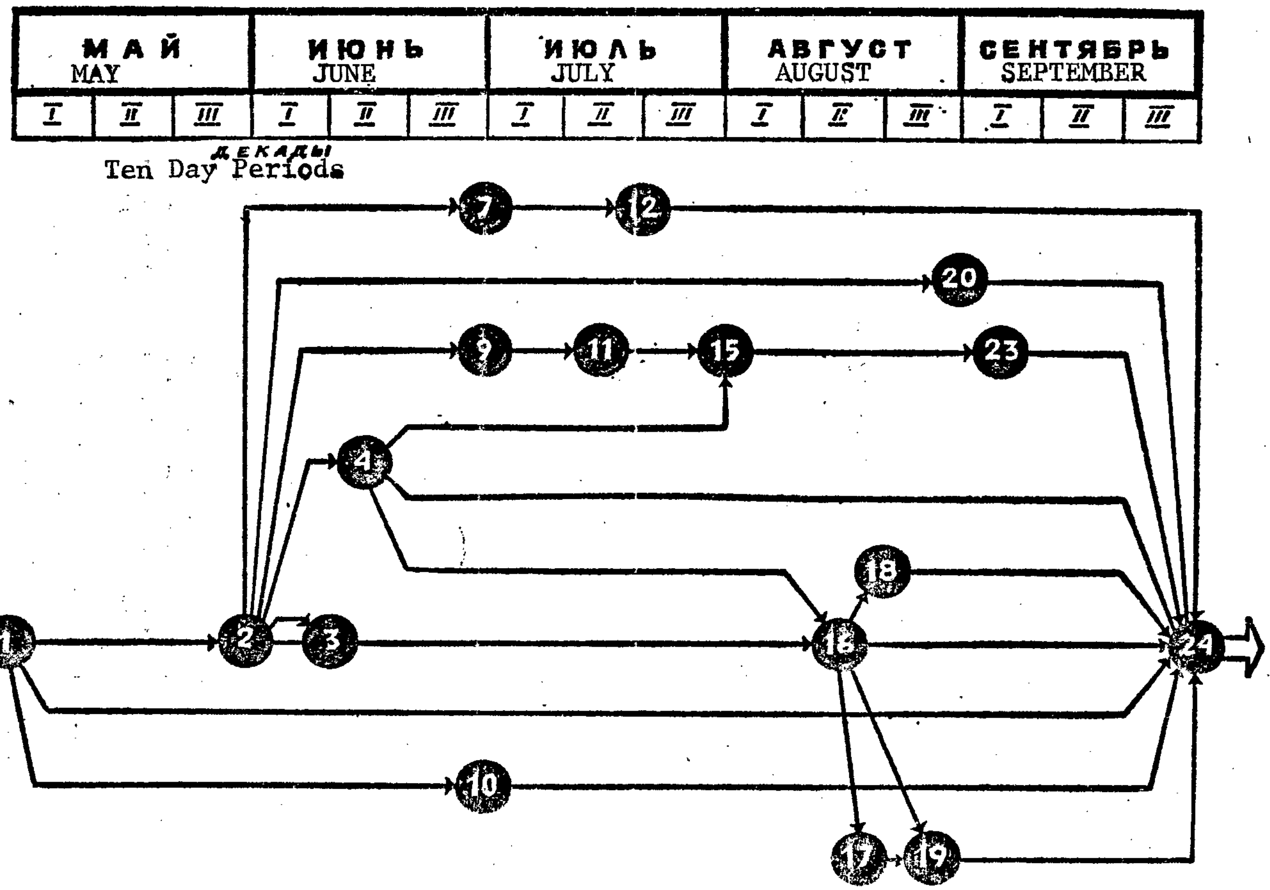
Shown above [on the next page] is an expanded network flow chart for the development and placing in production of a microcalculator (MK), in which the "operations" are indicated by the lines, while the beginning or conclusion of operations is indicated by the numbers. As can be seen from the chart, the developmental design work for the new product began at the beginning of May, and starting on October 1, 1976, the product went into series production.

As can be seen from the expanded network flow chart, the following were carried out simultaneously in the design office during May: the development of the design documentation for the parts of the microcalculator (1 - 2), the fabrication of a trial batch of the "BIS" [LSI] -- large scale integrated circuits for the first series of microcalculators (1 - 24), and the working out and issuance of the design and technological ducumentation for the digital display (1 - 10).

After completing the development of the design documentation and issuing copies to the corresponding subdivisions of the NPK [scientific and production complex], work got underway on a broad front starting on June 1. The following were completed in June: the work-up of the data sheets and instructions for the operation of the microcalculator (2 - 7), the development and

EXPANDED NETWORK FLOW-CHART FOR DEVELOPING AND PLACING A MICROCALCULATOR IN PRODUCTION

УКРУПНЕННЫЙ СЕТЕВОЙ ГРАФИК РАЗРАБОТКИ И ОСВОЕНИЯ МИКРОКАЛЬКУЛЯТОРА



In this way, the organizational combining of the production and design-production process subdivisions into a single complex was assured.

In step with the creation of the complex, its organizational and economic bases were specified more precisely, the interrelationships both between the structural subdivisions of the NPK [scientific and production complex], and between the complex itself and the centralized services of the association were polished. As a result, the requisite normative documents were developed -- regulations on in-house accounting, the sequence of planning and the organication of scientific and production activity, the conditions for socialist competition were made more precise, as were the systems for material and moral incentives. All of this is directed, within the complex, towards sharply curtailing the timeframes for the development of and setting up series production for new equipment, as well as continually decreasing expenses and improving the quality of the finished product.

The workers themselves had to effect an internal realignment, and of course, primarily the designers. Now, within the complex, their tranditional functions -- assuring the high quality of the design and testing experimental models -- proved to be too narrow. It was necessary to elevate the role and importance of designers in accelerating technical progress. In line with the new order, their activity came to be evaluated as a function of how rapidly and with what expenditures of labor and material resources the series production of new equipment gets underway.

The continual refinement and rapid replacement of products, the constant increase in the number of product types to be placed in production, and at the same time the necessity of maintaining a high level of design quality in the process of series production, all of this confronted us within the NPK with the urgent problem of the technical re-equipping of production and the refinement of technology.

We found the key to the solution of these problems in the long term comprehensive planning of measures related to the refinement of production, and in making a transition to through-planning of the scientific research and experimental design work with due regard for the continuity of the "research -- -- development -- production preparation -- series production" cycle.

Such an approach has permitted the NPK collective to sharply renew production and, in only the last three years (1974 - 1976), to reduce the labor intensity for the fabrication of products by more than 250,000 man-hours. On the whole, over the years of the Ninth Five-Year Plan, with the same force, the volume of production increased significantly, production of 60 new types of products was set up, and the quality of all products increased. We are expanding on this experience in the current five-year plan.

Today, it can be said, we have already put together a clear-cut order for the planning of NPK activity, the basis for which is the comprehensive, through flow charts for the creation and production start of new products. A system for monitoring the adherence to these flow charts has also been established.

fabrication of the photographic template for the printed circuit board (2 - 9), the issuing of requisitions for material and engineering supply services for the component products and materials (2 - 4), and the working out of charts for the tooling-up (2 - 3).

Also started during the same period were: the development, agreement on and approval of the technical specifications (2 - 20), the supply of materials (4 - 15) and component products (4 - 24), and the supply of materials for the fabrication of parts and tools (4 - 16). Conducted in parallel with this was the planning and fabrication of the tool equipment and the tooling-up (3 - 16).

In July, along with the continuation of the previously started operations (2 - 20, 4 - 15, 4 - 24, 4 - 16, 3 - 16, 1 - 24), the following were completed: the artistic packaging of the data sheets and instructions, and the order was placed for their manufacture (7 - 12), the testing of the printed circuit board (9 - 11), and the correction of the photographic template (11 - 15). The production of the digital displays (10 - 24) was started the same month.

Started in August were the fabrication of the parts for the microcalculators (16 - 24), supplying the shop-manufacturer with the plastic parts for the first series of microcalculators (18 - 24), fabricating the front panels (17 - 19), and their chemical processing (19 - 24).

In September, the prices were drawn up and approved (20 - 24), and the fabrication of the printed circuit boards was started (23 - 24). By the end of the month, all planned operations had been completed, and series production of the new products was begun on October 1.

Thus, thanks to the combining of stages in the design development and preparation for production, and the simultaneous conduct of these operations, series production of the new product was begun in as little as five months, where previously 12 to 14 months were required from the start of design development until series production.

The Effect of the New Structure

The chief of the scientific and production complex for electronic instrements, Yuriy Semenovich Sergeyev, talks about it:

The collective of our complex has been the first to pave the road to new forms of managing the technical progress in the association. Included in the complement of the complex are the design and production process subdivisions of the main plant, which specialize in the development of electronic devices, and a number of production shops of the "Svetlana" plant. The operational administration of the shops has been assigned to design office management.

This has created the capability of implementing a uniform technological policy, which encompasses all stages of the cycle -- from development to series production of the new equipment. Now the design and production process subdivisions, after completing the developmental work on a new product, immediately issue the set of series documentation. Cases where any changes at all are made in this documentation in subsequent operational stages have been practically eliminated, either during the time for production preparation or at the start of series production.

The refinement of in-house cost accounting, to which our subdivision has also made a transition, and the other scientific and production complexes created in the association, have promoted the acceleration of scientific and engineering progress. A system of sanctions has been worked out, which can be applied upon mutual complaints. Thus, the untimely issuance of technological documentation for the preparation for series production entails a reduction in the material incentive funds intended for rewarding the collectives of designers and technologists.

Naturally, you do not create a coherent collective with one realignment of the structure. Painstaking ideological and educational work is necessary. This is also being expanded on a broad front by party, trade union and komsomol organizations of the design and production subdivisions. We have received considerable support and assistance in all stages of establishing the NPK from the party committee and the general directorate of the association.

All of this work is primarily directed towards inculcating a sense of responsibility and concern in each worker for the high end results of the activity of the entire collective.

Socialist competition has also been elevated to a new level, which is now being conducted not only between the shops, but also between the NPK's. When the totals for the competition are added up, taken into account are the meeting of the cost accounting indicators, and the curtailment of the period for research, development and the production start of new products. Competition for the title of best specialist has been promoted on a wide scale in the NPK: the "Best Designer", the "Best Technologist", etc. An ever increasing effect is being felt from the movement, which has been developed on a wide scale in the production subdivisions of the complex, and started at the initiative of the brigade of M. Mironovaya. I would like to note that competition for the title of "The Brigade of Efficient Work and Outstanding Quality" is promoting not only an increase in such an important indicator in our case as the output of serviceable products, but also an acceleration of the production start for new products with the least expenditures.

In the photograph: new literature on "Svetlana" [not reproduced].

The Basis for Shop Competition is the Final Result

The chief of the NPK shop for electronic instruments, Nikolay Aleksandrovich Nazin, talks about it:

We, the production workers, you see, feel all of those positive changes most sharply which have taken place in connection with the creation of the NPK's. These changes concern not only the organization of production and labor, but also the in-house accounting, socialist competition and educational work.

Previously, such prototypes of devices frequently came to us in the shop that we could not put in series production right away: the technology, the materials, the equipment, and tooling were not up to it. But this is understandable; in designing new devices, designers oriented themselves on the experimental base of the scientific subdivisions, where the personnel are more qualified and the equipment is better. Now, work has gone more rapidly since the management and goals have become the same for us, and since the designers are developing designs taking into account the series production technology and which come up to not only the high quality of the model, but also of the series production. And although the priority remains in the scientific sector (heading up the NPK is the chief of the design office), it is possible for us production workers to much more easily resolve the complex problems of setting up new production, and accelerate this process. For the management of our complex started devoting the most intense attention to the development and refinement of production right at the outset.

The general orientation towards the final result has drawn the collectives of the design and production process subdivisions and the production shops closer together. Joint dispatcher controller conferences have come to be held, and those questions of the preparation for production and setting up production for new products which previously took up an enormous amount of time for the heads of the departments and shops, are now being solved in an operationally timely sequence.

We have also become convinced of this in practice in the NPK work force, and for the collective of each shop there are greater possibilities for increasing the indicators of production efficiency and work quality. And this is only natural since the conditions for refining production have objectively improved, as have those for taking steps to comprehensively mechanize and automate, and employ more progressive equipment and technological processes. Just through introducing the method of electrical spark treatment of parts into production, for example, did the output of servicable products in our shop increase by more than one and a half times.

And I would cite yet one more social and political effect from the creation of scientific production complexes. The close interaction of the collectives of the scientific and production subdivisions has mutually enriched to a considerable degree the workers of the complex, and increased responsibility, creative initiative and the active involvement of the workers. The effective results of socialist competition have grown, as has the educational work as a whole.

In one of the association shops. Photo by V. Tokarev [not reproduced].

The Curtailment of the Time Periods for Developing and Placing New Products in Production

(in months)

Time Periods	Product 1	Product 2
The plan timeframe for development and placing in production	60	32
The actual timeframe for development and placing in production	44	21
The time curtailed from the period for development and placing in production	16	11

A system of cost accounting indicators, which orient the collectives towards an increase in the quality indicators of the work, has been established as the basis for competition between the shops of the complex. It should be noted that the association has completely dispensed with the practice employed for many years of giving bonuses to the collectives of the shops and sections for overfulfilling the plan assignments. Today, the size of the material incentive funds is set up in direct proportion to the effort involved in meeting the plans.

The shop material incentive funds are created on the basis of a different procedure than the plant funds. Part of the shop fund, which is intended for worker bonuses, is produced in accordance with a single standard for all shops: as a percentage of the plan fund for the wage scale of the workers. These funds are used in accordance with the regulations for the awards, as a rule, for the quality indicators of the work during the obligatory fulfillment of the production plan figures as regards reducing rejection losses, savings in parts, semifinished products, electrical power, and for the level of product delivery beginning with the first claim.

Another part of the shop fund, which is intended for bonus awards to engineering and technical workers, and office employees, is determined in accordance with a system of norms depending on the growth rates of the fund generating indicators. In this case, even before the onset of the plan period, the corresponding scales, in accordance with which the specific scope of the awards is determined, are developed or reconfirmed.

For assembly shops, for example, the scale of bonus awards for engineering and technical workers, and office employees, is set up taking the growth of the two fund generating indicators into account, which characterize the efficiency: these are the increase in labor productivity and the reduction of shop production costs. Thus, the scale in force for this year provides for the following: for a three percent increase in labor productivity with respect to the plan over that for 1976, set aside in the shop fund for bonus awards to engineering, technical, and office employees is 20 percent of the total of

their regular salaries; for an increase of 10 percent in labor productivity, 34 precent is set aside. A special scale of allotments is established for reducing production costs.

In summing up what has been said, I would like to once again underscore the fact that all of the measures related to the creation of the NPK have one goal: to accelerate scientific and engineering progress in the association. And practice has shown that the organization of scientific and production complexes is the true path to achieving the set goal.

To Brigades of Outstanding Quality

Brigade leader and installer, Mayya Mikhaylovna Mironova, talks about it:

Our brigade is one of the first in the association which in 1976 was awarded the title of "Brigade of Efficient Work and Outstanding Quality." It was not easy to achieve victory in the competition for the right and be awarded such an honor; we had to put out quite an effort.

And the fact of the matter is not only that the product which we produce is rather complex, and requires jeweler precision in the assembly. In our scientific and production complex, just as, by the way, in the association as a whole, all production is like this. And much depends here on skill and a responsible approach to the work.

In the brigade which I head up, there are seven people. Three of my friends, Valya Bezborodova, Nina Davidovskaya and Tamara Petukhova, just as myself, are rated in production class four, and have considerable work experience in the primary assembly operations. The remaining members of the brigade have considerably less work experience: Nada Yershovaya, Nada Smirnovaya and Tamara Sokolovaya. Naturally, the "assembly veterans" have shared their experience with the newcomers, and helped them to increase their skills.

But with the creation of the NPK, we had new opportunities to step up the fight for efficiency and quality. Right now, we particularly feel the assistance of the engineering and technical workers in refining the organization of the work locations, and the assembly technology. And it could not be otherwise: the designers and workers now have common assignments in the series production stage. And the initiative for our brigade: "From the workers -- those distinguished for excellent work quality -- to the brigades of efficient work and outstanding quality" is in many respects indebted to just this creative union with designers, who are directly interested in the success of the production workers and assist us in every way.

But you see, one can approach this assistance in different ways. For example, you can patiently wait for it without taking any initiative on your own. Our brigade takes the opposite position. We suggest to the shop management and designers what must be imporved. For you see, as they say it is more visible to us on the job. This was the case, in particular, with the improvement of

the installation workbenches, on which instruments were assembled from parts which could be differentiated only through a microscope. On our initiative, more more progressive sequence was developed in the shop for the set-up of the installation workbenches, which substantially increased the work quality of the assemblers.

The labor efficiency of the brigade, and the final result of the work of the entire shop, depend quite heavily on the mutual responsibility of the subcontractors. Of course, as before when defective parts are received for installation, we rejected them and returned them to their own work locations. But this was an unproductive expense of our work time. In starting the competition for high labor efficiency of the brigade and product quality, we turned to the brigades of related sections with the proposal that work be evaluated based on the final result.

The efficacy of this competition is assured by a system of moral and material incentives, the openness and operationally timely totalling of the work results. The brigade knows the totals for each day and month, and no later than eight days after the end of the regular quarter, the quality control department puts out the data on the average indicator for product deliveries with the first claim, according to the groups of the competing brigades. In coming up with the totals, also taken into account is the level of meeting the production norms by each member of the brigade, and the absence of instances of violations of production process and labor discipline.

If in a biennium a brigade delivers all products with the first claim, it is awarded the title of "brigade of efficient work and outstanding quality." In this case, at a general shop meeting the brigade leader is given certification of the right to deliver products without notifying the controller of the quality control department. All the members of the brigade are listed in the certification. We have become convinced just what favorable effect such a custom has on increasing collective responsibility.

The collective of our brigade has already held the right it won to a brigade quality control stamp for a year and a half. Over this period of time, our output of serviceable parts has increased eight percent.

The development of the competition for the title, "brigade of efficient work and outstanding quality", has promoted an improvement in the indicators as whole in our shop. Just in the last year, due to the increase in the output of serviceable products, the economic effect exceeded 10,000 rubles. The average indicator for product deliveries with the first claim also improved markedly.

In honor of that famous date, the 60th anniversary of the Great October Revolution, our shop, just as the entire collective of Svetlana workers, has taken on the obligation of completing the assignments of two years of the five-year plan ahead of schedule, on the 7th of November.

Brigades of Efficient Work and Outstanding Quality

(From the regulation on brigade competition in the "Svetlana" association)

The title, "brigade of efficient work and outstanding quality", can be awarded to brigades, all the workers of which show initiative in improving product quality, deliver their products with the first claim, fulfill and overfulfill the production norms, and strictly observe technological and production discipline.

The brigade leader of a brigade which is awarded the title is issued a certificate for the right of delivering products without submitting them to the quality control department controller, and a personal stamp for drawing up the accomanying documentation for the finished products. Enumerated in the certification is the membership of the brigade of outstanding quality.

Gaining the title of "brigade of efficient work and outstanding quality" confers the right to deliver products without presenting them to the controller.

The members of a brigade of outstanding quality have favored status in obtaining travel vouchers to health spas, vacation homes, one-day rest centers, for trips, and other events.

The members of a brigade of outstanding quality are paid the following bonuses monthly from the material incentives fund: pieceworkers -- in the amount of 10 percent of the piecework wage scale, and time workers, in the amount of 10 percent of the wage scale for the work grade acquired. The indicated bonus is not paid for months in which a reject was detected, there was violation of technological or production discipline, or the production norms were not met.

The members of a brigade of outstanding quality are obligated to check the products manufactured by them strictly in accordance with the requirements specified in the drawings or other documentation.

The members of a brigade of outstanding quality bear the responsibility for the correctness of the monitoring; and for the passing of a reject, regardless of when and where it is detected.

8225
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CYBERNETICS, COMPUTERS AND AUTOMATION TECHNOLOGY

AUTOMATED POWER CONTROL SYSTEM NOMINATED FOR STATE PRIZE UZBEK SSR

Tashkent PRAVDA VOSTOKA in Russian 19 Oct 77 p 2

[Article by candidate of technical sciences Z. Salikhov, chairman of the Scientific Labor Organization Administration of Power and the Electrical Equipment Industry, Uzbek SSR, and candidates of technical sciences E. Payziyev, N. Usmankhodzhayev and Yu. Zhuravlev]

[Text] The next few years will be characterized by the further development and technical progress of Soviet power engineering. The production of electric and thermal energy will increase and the length of electrical and thermal networks will grow. This will complicate the functions of the administration of power engineering. It suffices to say that the workers of the Uzbek power system alone use over 200 million indicators each year. Under those conditions, preservation of the previous system of administration threatens loss of controllability, as the volume of information starts to exceed the limits of human possibilities. Only the introduction of new technical equipment capable of performing the storage, retrieval and processing of information can assure the required level of controllability.

The power workers have taken a course toward the development of a branch automatic control system. The Uzbek power system was one of the pioneers of that undertaking.

In what does the automatic control system of the Ministry of Power and Electrification Uzbek SSR consist? The authors of the system -- A. Kh. Khamidov (leader), V. A. Bykov, T. A. Valiyev, A. V. Drobov, P. N. Suleymanov and F. Sh. Khairov -- proposed original methods of solving problems of operational and organizational and economic management. The branch automatic control system embraces management of the power system of Uzbekistan on all levels, starting from the large substations and ending with subdivisions of the ministry. Such a distinctive feature of the Uzbek power system as the variety of capacities and of the technical level of installations is also taken into consideration in that case.

The creation of an ACS made it possible for the ministry to exclude many operations in the gathering, storage, retrieval and processing of accounting and statistical information. A complex of programs was prepared and introduced for the solution of tasks in operational planning and analysis of the working conditions of the Uzbek power system, based on optimization methods. A man-and-machine system of operative control of production processes and the distribution of electric and thermal power was introduced.

As was noted in his report at the 19th Congress of the CP Uzbekistan by member-elect of the Politburo CC CPSU, first secretary of the CC CP Uzbekistan Sh. R. Rashidov, the Minenergo ACS is the first in the republic successfully created and functioning. It solves over 100 problems of the operative, dispatcher and organizational and economic management of the power system. Among the greatest value is presented by problems of automatic dispatcher control. Their introduction has permitted predicting the loads on future days both for the power system and for separate areas of it and distributing the proposed load among the electric power stations with consideration of the available water for hydroelectric power stations, the cost of different types of fuel for thermal electric power stations and losses of power in the main electric power transmission lines.

In speaking of the automatic system one cannot neglect a complex of tasks in the analysis of the technical and economical working indicators of thermal electric power stations. About 70% of the cost of electric power consists of expenditures on fuel. The efficiency of calculations made it possible at a number of electric power stations to more correctly organize competition to save fuel. Thus, in 1971-1976 the proportion of standard fuel per produced kilowatt-hour was successfully reduced by 10.4 grams at the Angenskaya GRES and 79.1 grams at the Ferganskaya TETs. Expressed in money the savings for the same years were 357,800 and 1,629,600 rubles respectively.

Another main problem is the automatic system for management of organizational and economic activity, including a complex of tasks in the supplying of materials and equipment, the supplying of fuel, the sale of energy, and labor. The computer maintains a record of the input and output of commodity and material values, the level of stocks of a given products list, compiles a daily circulation report and issues notices about the presence of given commodities.

The importance of automation of those operations is estimated not only by the rise of the technical level of control of resources but also by the fact that the circulation of a considerable quantity of commodity and material values is accelerated, stocks are diminished, commodities without demand are revealed and measures are effectively adopted to optimize the levels of stocks. Questions of control of fuel stocks at the stations are solved similarly.

One must note an extensive library of power engineering programs, many of which are the best in the country. Because of their legitimacy and universality they have been adopted for introduction by other power systems:

Mosenergo, Donbassenergo and Kievenergo. The successful functioning of a branch automatic control system has been determined to a great extent by equipping it with third-generation computers and an entire series of devices assuring teletype, telegraph and telemechanical communication with objects disposed all over the republic. It has been shown that it is advisable to use electric power lines as data transmission channels, and this has made it unnecessary to create new and costly communication channels. Technical means of display control, subscriber points and graph constructors are being used successfully.

The information obtained by means of such equipment makes it possible for a dispatcher to make correct decisions regarding correction of the work of a power system and trace the reasons for accidents. The authors have skilfully used methods of special mathematical, engineering and economic disciplines and also methods of the theory of optimization, the theory of decision making, information retrieval and programming.

The economic effectiveness of the branch automatic control system by the end of 1974 was over 1 million rubles. That saving will increase from year to year through improvement of the calculation algorithms and increase of the number of problems to be solved.

In the process of creation of the system, highly qualified programmers and software developers were trained.

The high scientific and technical level of the Uzbek power system ACS has been acknowledged by specialists and the scientific and technical community of power engineers of the country. By order of the Ministry of Power and Electrification USSR it has been designated the leading organization in the introduction of ACS of the country's power systems. Work on the further development of the Uzbek power system ACS has been included in the program of most important scientific and technical problems for 1976-1980. Our ACS won first place at the Exhibition of Achievements of the National Economy of the USSR.

The system is now functioning successfully and bringing a large saving to the national economy. In the tenth five-year period production of electric power in the Uzbek SSR will increase 20% and reach 40.5 billion kw-hrs.

Taking into account the great economic effectiveness of the Uzbek power system ACS and also the high scientific and technical level of the solved problems, we support the proposal of that work in the competition for the State Prize of the Uzbek SSR imeni Avu Raykhana Beruni for 1977.

2174
CSO: 1870

ENGINEERING AND EQUIPMENT

ACHIEVEMENTS OF CENTRAL SHIP DESIGN OFFICE

Moscow MORSKOY FLOT in Russian No 9, 1977 pp 48-50

[Article by V. Yevstifeyev and M. Shmakov: "Vympel Central Design Office Working for the Merchant Fleet"]

[Text] The Vympel Central Design Office is celebrating its 50th anniversary.

Prior to the war seagoing and harbor barges of various types and tonnages, small coal and ore carriers, unpowered tanker barges of light and heavy refined products, ranging from 330 to 6,600 tons, dirt and rock hopper barges with capacities ranging from 250 to 1,000 cubic meters, and seagoing tugs from 450 to 800 horsepower were built from designs originating at the Central Design Office. Steam propulsion units, boilers, deck machinery as well as other equipment were designed for these vessels.

At the very outset of the Great Patriotic War Vympel shifted over entirely to military design projects. More than half of the design office staff went into the army and navy. The remaining personnel labored selflessly on refitting existing and designing new warships.

After the war the Central Design Office [CDO] proceeded with designing new vessels of various types, such as tankers, dry-cargo vessels, railroad and passenger-car ferries, air cushion vessels, tugs, etc.

Designing of tankers began with the shallow-draft combination service tanker "Oleg Koshevoy" (1954). Tankers of the "Inzhener Pustoshkin" class (1957) constituted the second generation of these vessels. Today our merchant fleet contains more than 30 vessels of these types, which have become the nucleus of the Caspian tanker fleet.

The "Inzhener Belov," first in a series of shallow-draft seagoing cotton-lumber carriers, was built and commissioned in 1959. At present our fleet contains more than 20 vessels of this type, which formed the basis of the Caspian dry-cargo fleet. Some of these vessels are presently working for the Northeastern Merchant Fleet Administration.

Good results from operating cotton-lumber carriers of the "Inzhener Belov" class on a number of seas served as a basis for development of second-generation shallow-draft dry-cargo vessels of the "Kishinev" (1968) and "Sovetskaya Yakutiya" (1972) classes. They differ from first-generation vessels in that they are totally automated. Motor ships of the "Sovetskaya Yakutiya" class also possess improved ice-handling capability.

"Azovstal'" class sintered ore carriers were developed for the Azov Steamship Company, based on "Kishinev" class dry-cargo vessels, a class which is continuing to be constructed. "Azovstal'" class vessels are for carrying sintered ore at temperatures up to 700°C between Kamysh-Burun and Zhdanov, replacing 3,200 ton unpowered lighters and 800 and 1,200 horsepower tugs. All transverse bulkheads in the cargo hold area were removed on these vessels, and additional bulkheads installed -- second sides -- to facilitate loading and off-loading sintered ore.

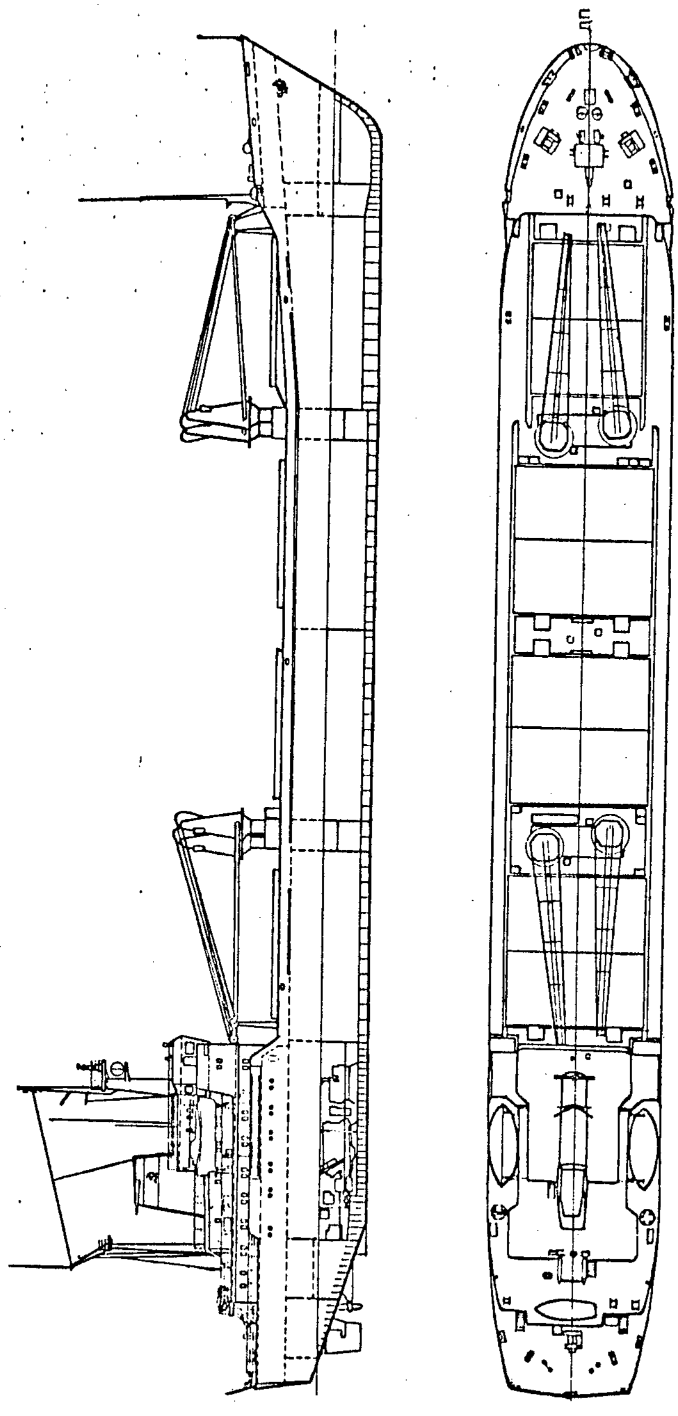
The work force at the Vympel CDO is continuing work on improvement and further development of combination-service shallow-draft seagoing vessels. Recently there arose the necessity of replacing tankers of the "Oleg Koshevoy" class, which have been operating effectively on the Caspian for more than 20 years. In connection with this a shallow-draft third-generation tanker, the "Zolotoy Zaton," was designed in 1970. It is planned to build vessels from this design at foreign shipyards.

They will have greater deadweight tonnage than first and second-generation tankers, as well as special ballast tanks, which will prevent polluting the seas. Control of cargo handling operations, tank cleaning and ballast systems, as well as remote measurement of cargo level and monitoring of cargo state will be handled from a cargo operations control station. Improved cargo and washing systems as well as a cargo warming system will reduce tanker down-time in cargo transfer operations.

In 1974 the CDO designed a a shallow-draft universal vessel adapted for transporting containers. The first motor ship of this class, to go into operation in 1977, has been christened the "Vasiliy Shukshin." It represents a third generation of shallow-draft seagoing dry-cargo vessels. The new ships will be faster than the first-generation vessels, will have greater propulsion plant automation, are better equipped for cargo handling operations, and offer improved crew living conditions.

For more than 30 years now Vympel has been designing railroad and passenger-car ferries. The railroad ferries operating on the Kerch', Caspian and Sakhalin crossings were designed at the CDO. Passenger-car ferries serving crossings in Sevastopol' Bay, on the Lomonosov-Kronshtadt line, and across the straits of the Moonzund Islands (in Estonia) were also designed at Vympel.

The Kerch' ferry service, 2.4 miles across, went into operation in 1955. It shortened travel between the Crimea and the Caucasus and provided year-round service for freight and passenger consists as well as automobiles and



General View of Shallow-Draft Universal Vessel "Vasiliy Shukshin"

passengers across the Kerch' Strait. The service is provided by four ferries. This ferry service is the first to carry scheduled passenger trains together with passengers.

The Kerch' ferry service is of great importance to the nation's economy, but it no longer meets today's demands. The Vympel CDO is designing a new ferry for the Ministry of the Maritime Fleet. This new ferry will make it possible to meet increased demand for passenger service and will provide the capability of year-round service with an open deck accommodating the full passenger complement.

Caspian ferry service is handled by five diesel-electric ferries of the "Sovetskiy Azerbaydzhan" class. The first of these ferries went into operation in 1962. The crossing substantially shortened the run for rail consists within the unified transportation system.

Sakhalin ferry service, running between Vanino and Kholmsk, began in 1973. This crossing is presently served by five diesel-electric ferries. Ferry service on this crossing is producing considerable economic effect and is promoting accelerated development of that region.

Ferries of the "Sakhalin" class are unique vessels. They are designed for carrying all types of rail rolling stock, wheeled and tracked vehicles, as well as passengers in comfortable facilities. A high degree of automation, remote control and monitoring make it possible to run and monitor the propulsion plant from the control center without standing continuous engine-room watch.

One of the main directions taken in CDO activities is the designing of vessels for the technical fleet. A series of versatile self-propelled full-slewing 50 ton cranes, capable of operating in high seas, was built (1952) from plans designed at this office. The CDO designed the "Ker-Ogly," a 250-ton double-hulled crane ship, which was built in 1965.

More than 50 steam and diesel 500 cubic meter hopper barges have been built from designs developed at Vympel.

At the present time the Vympel CDO is working on the "Zyuyd," an 1,800 horsepower harbor tug designed to lead vessels of various types and tonnage into and out of port, to assist them in docking, as well as to assist in putting out fires on vessels and in port facilities.

Small in size, the "Zyuyd" will contain a twin-shaft diesel propulsion plant with reduction gears, with 900 horsepower medium rpm engines, variable-pitch screws in separately-controlled steering nozzles, and main engine-driven fire pumps with a total pumping capacity of 150-250 m^3/h. This vessel, equipped with remote control and automation devices, will be run by a three-man watch crew.

The vessel's design, which provides built-in protection to screws and rudder from floating ice, will give the tug capability to operate in freezing-over

ports. A single person can operate the vessel from the elevated wheelhouse. The vessel is to be equipped with a remote-control system for releasing anchors from the wheelhouse, devices mechanizing winding the heavy towing cable on the tow hook, as well as an automatic hook release system.

Since 1961 the CDO has been engaged in research and design of air-cushion vessels without total separation from the water (skeg or side-wall design). Initially the office conducted extensive experimentation, designed and built several small experimental air-cushion craft. This was followed by designing and building full-scale vessels.

The "Chayka," first of a series of side-wall air-cushion vessels, was built in 1976, and the work force at the CDO is presently working on the plans for another side-wall air-cushion vessel.

A large number of vessels built on designs produced at the Vympel CDO are in service in the Soviet merchant fleet. And new designs are being born on the drawing boards and in the laboratories of the design office.

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PHYSICS AND MATHEMATICS

AUTOMATION OF OPTICAL ELEMENT ADJUSTMENT IN A LASER INSTALLATION

INTRODUCTION

Moscow AVTOMATIZATSIYA YUSTIROVKI OPTICHESKIKH ELEMENTOV V LAZERNOY USTANOVKE in Russian Preprint No 135 1977 signed to press 19 July 1977 pp 1-34

[Introduction from the book "Avtomatizatsiya yustirovki opticheskikh elementov v lazernoy ustanovke" by V. S. Yegorov, V. G. Ilyushin, Yu. N. Kal'chenko, N. V. Pletnev, Yu. V. Senatskiy, G. V. Sklizkov, L. K. Subbotin and S. I. Fedotov, Laboratory of Quantum Radio Physics of the Physics Institute imeni P. N. Lebedev, 100 copies 34 pages]

[Text] A great deal of attention is now being devoted to problems of automating the adjustment of large laser installations installed in a number of laboratories for experiments in laser thermonuclear fusion [1-5]. The complexity of the optical circuit, the multicomponent nature and the long length of the optical channel and the difficulties of aiming and focusing of many laser beans onto a small spherical target -- these characteristic features of laser thermonuclear experiment determine the need to automate adjustment. One of the most widely used operations in adjustment of the laser installation is orientation of the optical components contained in it (mirror, prism and so on) by spatial and angular coordinates. This operation is also required in tuning the cavities in driving oscillators and in transport of the laser beam through the optical channel of the installation and also in aiming the beams onto the target.

The problem of automatic adjustment of the optical elements can be solved by using a complex of local closed tracking systems which control adjustment of individual optical elements during computer control of the entire complex.

The principles of constructing local automatic control systems (ASU) for adjusting the optical elements in a laser installation are considered in this paper. The block diagram and the technical possibilities of realizing individual components of the ASU and also the working principle and order of functioning of the effective model of the automatic mirror adjustment subassembly which provides precision of aiming the laser beam in a given direction not worse than 1" are considered. Schematic solutions of adjusting the driving oscillator cavity in the powerful "Del'fin" neodymium glass laser installation are presented as a specific example [1, 2].

1. Principles of Constructing Automatic Control Systems for Adjustment of Optical Elements

The objects and problems of adjustment in laser thermonuclear experiment are very multifaceted and complex [3]. According to the classification given in [3], adjustment operations include not only spatial and angular orientation of the optical elements but also monitoring the optical quality of these elements, aiming and focusing of the laser radiation onto the target, monitoring the conditions of target irradiation and so on. We will be concerned in this paper only with the problem of spatial and angular orientation of the optical elements and will understand the term "adjustment" in the corresponding narrow sense of the word.

Thus, adjustment of an arbitrary optical system (for example, a laser) will subsequently be understood as spatial and angular orientation of the optical elements contained in it. The most widely used in laser installations have become methods of adjustment based on comparison on the spatial-angular orientation of the optical elements to the orientation of the adjusting beams which irradiate them. The spatial and angular coordinates of optical elements are brought into agreement with the optical circuit of the laser on the basis of analyzing the distribution of the adjusting beam intensity in the near or far zones. Accordingly, different specific adjustment circuits are constructed. Auxiliary devices which make it possible to fix the spatial coordinates of the adjusting beam and the optical elements are used in near-zone adjusting systems. For example, they include diaphragms, crosshairs and so on. Angular coordinate adjusting systems (in the near zone) are constructed, for example, by the principle of autocollimation circuits. These same principles are also the basis of the ASU for adjusting optical elements.

Adjusting ASU may be constructed by the principle of single-circuit closed systems from the viewpoint of the theory of automatic control systems. An example of the block diagram of such a system is given in Figure 1, where a simplified block diagram of an angular coordinate adjusting ASU is presented. The input value in the diagram of Figure 1 is the given direction (sighting line) in space φ, while the output value is the real direction of the optical axis of the adjusting laser beam φ'. The feedback circuit closes the automatic control system consisting of the control object (OU) -- the adjusted optical element, a feedback sensor (DOS), a measuring member ($\rightarrow\otimes$) or a discriminator -- for comparison with the given angular position of the object, an error signal amplifier (UM) and a drive or actuating device (IU) which acts on the control object. The function of the comparison device in this circuit is clear -- it forms an error signal e, equal to the difference of the input and output values, that is, $e = \varphi - \varphi'$.

The block diagram of the automatic control system of the adjusted element position by spatial coordinates (in the near zone) is also constructed in a similar manner. The input value in this system is the given spatial position of the adjusted element, which prevents spiraling of the laser beam, while the output value is its real position in space.

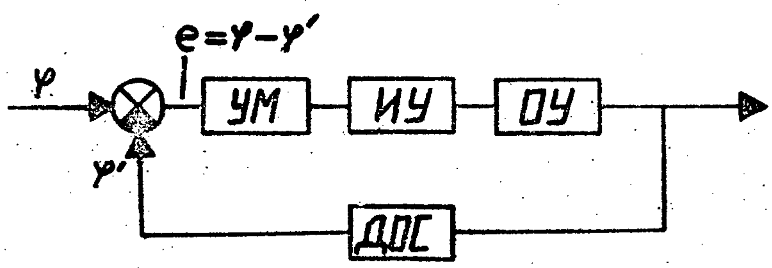


Figure 1. Simplified Block Diagram of Adjusting ASU: Notations: φ -- given direction in space; φ' -- real direction of the laser beam axis; e -- error signal at the output of the comparison device (discriminator); UM -- power amplifier; IU -- actuating device; OU -- control object; DOS -- feedback sensor

The far-zone automatic adjusting system (by angular coordinates) is of greatest importance for multibeam lasers for thermonuclear purposes with a long length of optical channel, since the angular coordinates of the optical elements are most strongly subject to the effect of destabilizing factors (mechanical fluctuations, temperature fluctuations and so on) and require automatic adjustment. Automatic near-zone adjusting systems may be required for individual optical subassemblies, but selection of a sufficiently large aperture for the greater part of the elements and fixation of the spatial position which prevents spiraling of the beams make it possible to avoid automatic correction of position. We shall devote main attention in this paper to automatic far-zone adjusting systems.

An adjusting ASU has a number of characteristic features which distinguish it from other ASU. The following most widely used systems may be distinguished among ASU (see, for example, [6]).

Tracking type systems in which the input value (φ) varies and is previously unknown and the output value (φ') tracks the position of the input value with some degree of accuracy by using a feedback system, that is, $\varphi' \approx \varphi$. Programmed control systems in which the input value (φ) is previously given according to a specific program (in a specific case there may be $\varphi =$ = const), while the output value (φ') tracks the position of the input value with some degree of accuracy by using a feedback system. Extreme control systems in which φ and φ' approach an extreme value during the search for the extremum. Adaptive systems are systems with a memory in which past and certain other actions are stored.

Adjusting ASU operate in the programmed control mode in which the input value is usually fixed and constant (given by the optical circuit of the laser). This makes it possible to create a stable automatic control system without introduction of correcting units in the feedback circuit.

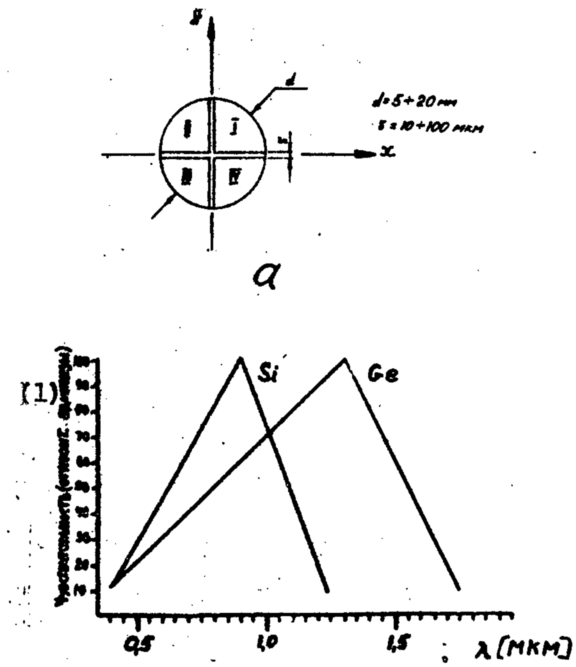
2. Realization of the Components of an ASU for Adjusting Optical Elements

Let us consider what the technical possibilities are of realizing individual components of the block diagram of the adjusting ASU in Figure 1. A number of technical solutions of the problems similar to the automatic adjustment problem is known. For example, automatic aiming of telescopes [7, 8] is similar to the problem of adjustment by angular coordinates. The problem of automatic copying [8] is similar to that of adjustment by spatial coordinates. Therefore, there should also be common aspects between the components of corresponding ASU.

Photosensors used in telescope aiming systems, for example: a tetrahedral reflecting prism with photomultipliers [8], a rotary semidisk with sharp edge and FEU [8], a television camera tube of the superorthicon type [9] and so on, could be used as the feedback sensors in an angular coordinate adjusting ASU. These sensors in automatic telescope aiming systems permit one to achieve an accuracy on the level of 0.1" [8], but they are very complicated to use. The so-called coordinate (quadrant) photodetector (KFP) used in the aerial bomb control system [10], Figure 2, a, is more preferable for mass use in angular coordinate adjusting ASU. This photodetector generates electrical signals proportional to the displacements of the adjusting beam position by two coordinates on this sensor. Silicon and germanium photodiodes, Figure 2, b, are most suitable for construction of ASU for adjusting lasers which operate in the visible and near IR bands. The integral sensitivity of these detectors comprises 0.1 + 0.15 A/W, while that for the visible band is approximately equal to 4 mA/lm, the sensitivity threshold is approximately equal to $5 \cdot 10^{-9}$ $lm \cdot cm^{-1} \cdot Hz^{-1/2}$, while the time constant $\tau \simeq 10^{-5}$ sec at dark current density $i_t \simeq 10$ $\mu A/cm^2$ [8, 11]. Detectors of this type may operate in two modes: the photodiode when power supply voltage is applied to the p-n junction, and the photovoltaic mode when there is no external power supply voltage.

Another important component of the automatic control system is the comparison devices (discriminators). They are divided by their functional designation into level, phase and frequency discriminators of the electrical signal [6]. Only level or amplitude discriminators of electrical signal are required when using a coordinate photodetector in comparison circuits. Differential amplifiers, to each of which are transmitted two signals from opposite sectors of the coordinate photodetector, can be used as these devices. The advantages of these amplifiers include the fact that generation of the error signal is not affected by variation of the luminous flux output impinging on the detector.

The next component of the control system is the power amplifier, which amplifies the electric error signal from the discriminator to the level required for the drive control. A control signal of different nature, for example, electrical pulses (current or voltage), pneumatic or hydraulic pulses and variation of the constant voltage (or pressure) level, may be generated at the power amplifier output.



b

Figure 2. Explanation to Working Principle of Coordinate Photodetector (a) and Averaged Spectral Sensitivity Curves of Germanium and Silicon Photodetectors (b): I-IV -- four independent photodiode field-sectors separated by a cross-shaped insensitivity zone; d and δ -- dimensions of the diameter and insensitivity zone typical for use in automatic adjustment problems

KEY: 1. Sensitivity (relative units)

Different technical solutions generally based on different physical phenomena such as the piezoeffect, thermal expansion of bodies, electromagnetic induction and so on, may be used as the optical element drive. The electromechanical drive has become widespread in engineering (see, for example, [7, 8, 12]). This drive is also convenient for solution of automatic adjustment problems. The drive subassembly consists of an electric motor and reduction gear which makes it possible to develop on its own shaft the moment required for moving the optical element.

The components of the spatial coordinate adjusting ASU are largely similar to those of the angular coordinate ASU considered above. A specific aspect is only the construction of the feedback sensor and discriminator. One of the important solutions for spatial coordinate ASU is transmission of a reference (scanning) pattern in the adjusting beam and analysis of the passage of this pattern through the apparatus of the optical elements by using a multielement detector, for example, a television camera tube or a multiline scanistor [13]. The discriminator in this problem may be a logic device which analyzes variation of the reference pattern at the output of the optical element and which generates the corresponding error signal.

3. The Model of the Subassembly of the Mirror Adjusting ASU for a Laser Installation

A mockup of the subassembly for automatic adjustment of the mirror by two angular coordinates with electromechanical drive was selected to develop the individual components of the structural diagram of the adjusting ASU (see Figure 1) and to determine the adjustment accuracy achieved in experiment (Figure 3). The angular orientation of the mirror is tracked in the following manner. The beam from a single-mode He-Ne laser of type LG-36A was aimed at a lithium niobate light shutter (13), controlled by electrical pulses from a G5-26 generator. The pulse length was 0.3 ms and the tracking period was 10 ms. The amplitude-modulated radiation passed through the telescopic beam expander with a spatial filter, through a diaphragm d = 3 mm and entered the adjustment circuit. The beam impinged on a mirror (1) at a small angle to the normal and after reflection was focused by lens 6, which played the role of a Fabry lens [7, 8]. It constructed an image of diaphragm d on the receiving area of the coordinate photodetector 4. The size of the spot in this case was equal to 520 microns. The laser radiation intensity distribution on the spot was sufficiently uniform without the presence of diffraction rings around the spot (the irregularity of intensity distribution around the spot was 10 + 20 percent). The coordinate photodetector was installed on a two-way table with micrometric slides which permit moving it in a plane perpendicular to the beam with an accuracy of ±10 microns. With these displacements, the laser spot was shifted as shown in Figure 3, b. The plate (5) split off part of the radiation onto a ground glass screen located at precisely the same distance from the plate as the coordinate photodetector. The dimensions and shape of the spot on the screen (and consequently on the photodetector) were monitored by using a microscope. The mirror (1) was sighted by using an autocollimation tube 16 with focal distance of 1,600 mm and angular resolution of 1". A standard planoparallel plate 17, which is the sensor of the reference autocollimation image of a grid with a scale numbered in angular measure, was installed in front of the tube.

The schematic diagrams of the automatic adjustment subassembly are presented in Figures 4 and 6. The schematic diagram of the coordinate photodetector and of the preamplifier is presented in Figure 4. The KFP operates in the photovoltaic mode. The signal at the KFP output in this mode reaches units of millivolts (the photodiodes are not saturated). It is then amplified in the preamplifier to values of hundreds of millivolts and units of volts. Preamplification is accomplished by a K284 UD 1V operational amplifier. The high input impedance of this amplifier ($R_{vkh} \simeq$ 1 Mohm) provides the capability of working with a high-resistance sensor which the KFP is. The amplification factor of the amplifier may be varied in steps 10, 100 and 1,000 times, which makes it possible towork with different types of photodetectors and with different illuminations.

The amplified pulses are transmitted to the comparison circuit located in the instruction block. A diagram of the instruction block (for one coordinate "x") is presented in Figure 5. The instruction block "y" has a similar

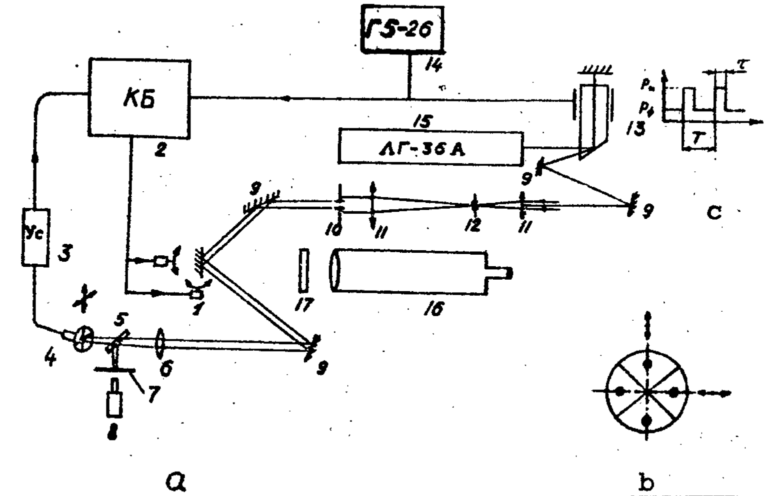


Figure 3. Installation Diagram of Bench for Study of the Characteristics of a Model Subassembly for Automatic Adjustment of a Mirror by Two Angular Coordinates: Notation: 1 -- mirror with electromechanical drive; 2 -- instruction unit (KB) for control of DC motors; 3 -- preamplifier; 4 -- quadrant coordinate photodetector; 5 -- planoparallel plate for beam splitting; 6 -- Fabry lens; 7 -- screen (ground glass); 8 -- microscope; 9 -- mirror; 10 -- diaphragm; 11 -- telescope lenses; 12 -- diaphragm (spatial filter); 13 -- laser beam intensity modulator based on $LiNbO_3$ crystals; 14 -- pulse generator (G5-26) for supplying power to the modulator; 15 -- LG-36A single-mode laser; 16 -- autocollimator with focal distance of 1,600 mm; 17 -- standard planoparallel plate; (a) -- diagram of bench; (b) -- pattern of light spot movements through coordinate photodetector; (c) laser radiation projection diagram by modulated $LiNbO_3$ crystal

diagram and generates signals arriving from a single pair of opposite sectors. The comparison circuit is based on the 1UT 401 A operational amplifier. The circuits of diodes D_1 and D_2 and of resistors R_{15} and R_{16} serve as a barrier to prevent noise of the preamplifier from penetrating the input of the comparison circuit during the pause between working pulses. The minimum restriction threshold is determined by the ampere-voltage characteristics of the diodes. It comprises approximately 200 mV for D18. The comparison circuit also amplifies the difference signal. The total amplification factor in the preamplifier-comparison circuit system reaches $5 \cdot 10^4$, so that the movement of the light beam through the photodetector, which causes variation of the difference of input signals by 0.1 mV, results in voltage variation from $+U_{max}$ to $-U_{max}$ and vice versa at the output of the comparison circuit (U_{max} = 2.7 V for the 1UT 401 A).

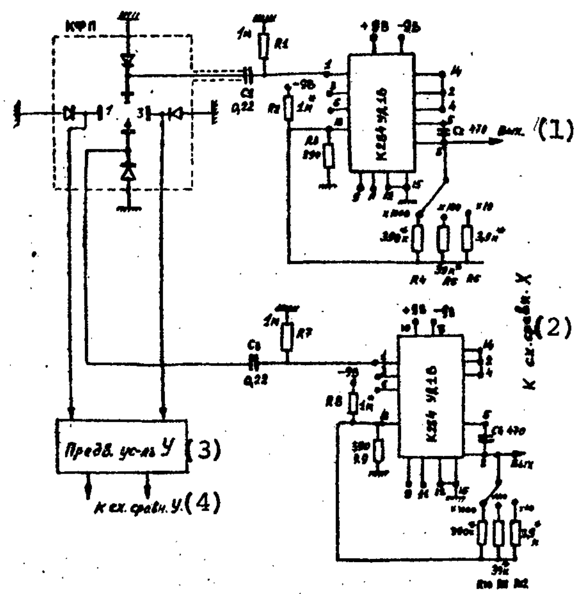


Figure 4. Schematic Diagram of Coordinate Photodetector (KFP) and Preamplifier

KEY:

1. Output
2. To comparison circuit X
3. Preamplifier U
4. To comparison circuit Y

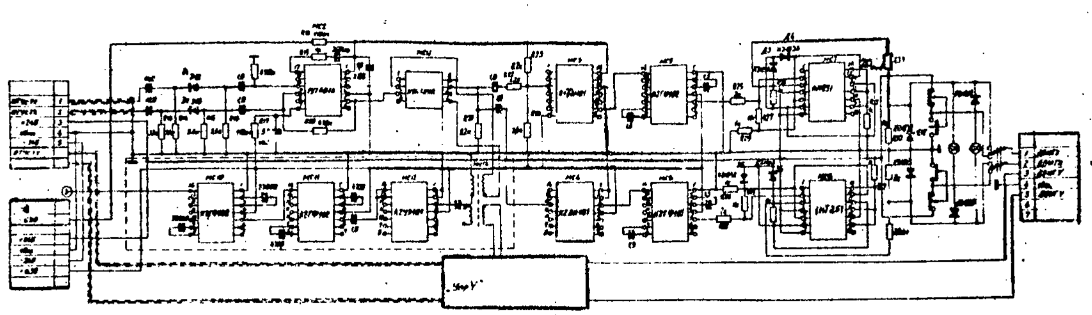


Figure 5. Schematic Diagram of Instruction Block of Adjusting ASU for Operating With DC Motors of Type DPM. The explanations are in the text

The next operating stage of the instruction block is "cutting out" the central part of the pulse received from the comparison circuit. This is done by the following concepts. When the light spot is shifted from the center to one of the sectors, the signal from the sector increases and a blip of opposite polarity appears on it which remains after the comparison circuit. This blip interrupts the operation of the following stages. "Cutting-out," which is accomplished by the KIKTOII A integral breaker, also serves to eliminate the effect of the blip on the circuit. It makes it possible to pass a pulse of any polarity during the time determined by the triggering pulse. This pulse of $\tau_i \simeq$ 10 microns forms the K2GF182 (MS 11)

monovibrator in the given circuit. The K2UE181 (MS 12) emitter repeater and the isolation pulse transformer Tr 1 transmits a trigger pulse to the breaker. The MS 11 monovibrator is triggered by a pulse delayed by approximately 150 μs -- have the length of the light pulse. The K2GF182 (MS 10) accomplishes the delay. It is triggered simultaneously with the optical modulator by a pulse from the G5-26 generator.

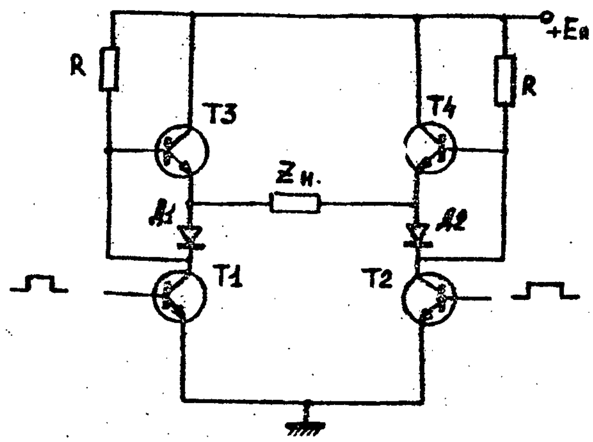


Figure 6. Schematic Diagram of Reversing Shaper in the Instruction Block

Two DPM-20 DC motors, which set the mirror on a gyroscopic suspension in motion through the reduction gears, were used as the actuating element which moved the mirror. The motors were rotated by transmission of pulses lasting 4 msec to their winding at a repetition rate of 100 Hz. The pulse polarity was changed to vary the direction of rotation. Commutation was accomplished by a bridge commutator built into two switches [14] (Figure 6). K1NT251 (MS 7 and MS 8) assembly transistors were used here as the active elements. These transistors have a low amplification factor; therefore, the elements of the bridge commutator are made on composite transistors. Display elements which permit one to judge either the direction of motion of the spot along the photodetector or in which sector the illumination is predominant are connected in parallel to the load (the motor winding). Monovibrators based on K2GF182 (MS 5 and MS 6) microminiature circuits form the motor starting pulses. The arriving pulse, for example, from MS 5, triggers transistor T_2 and causes current to pass through T_3, Z_N, T_2 and D_2 (Figure 6). The arrival of the trigger pulse from MS 6 triggers T_1. The current through Z_N changes its direction and consequently changes the direction of rotation of the motor.

MS 3 and MS 4 are components of the circuit which separate signals of different polarity into two channels corresponding to opposite movements of the light beam. MS 4 (K2LN181) is a pulse inverter of positive polarity and it does not respond to negative pulses. MS 3 (K1TSh181) is a Shmitt flip-flop and it is reversed only upon the arrival of negative pulses. Both circuits provide negative pulses at the output adequate to trigger monovibrator MS 5 and MS 6 with input signals of 1.7-2 V.

Both automatic and remote control of the mirror is provided. It is accomplished by buttons KN_1 and KN_2 (Figure 5).

The main characteristics of the automatic adjusting subassembly were investigated according to the experimental diagram presented in Figure 3. The test method was as follows. The energy center of energy distribution in the laser beam was joined to the KFP center by using the microslides of the receiver prior to the beginning of the experiment. The joining was monitored on an oscillograph by setting the signal amplitudes from the outputs of the comparison circuits to zero by coordinates X and Y. The position of the autocollimation image from the movable mirror (1) was then fixed with respect to a reference grid. The movable mirror was then shifted in angle by using the remote control buttons and the value of this shift was measured. The automatic guidance system was then switched on. Angular detuning by coordinates X and Y, comprising four angular minutes, was completed within 1-2 min to the "0" position with an accuracy up to 1" with laser radiation density on the coordinate photodetector of approximately $3 \cdot 10^{-4}$ W/cm^2. The accuracy of completing the system drops to approximately 10" with the reduction of the emissive power density on the coordinate photodetector by two orders. With regard to the other parameters (the shape and dimensions of the spot and the pulse length), no appreciable deterioration of system accuracy was observed with variation of them by more than 50 percent.

Variants of changes in the schematic solutions and the design of the instruction block and also three types of motor in the drive were considered when developing the model.

The optical radiation modulation in the circuit considered above was accomplished by pulses with $\tau_i \simeq 300$ μsec. Sinusoidal amplitude modulation is of interest. Its advantages over pulsed modulation should include: 1) the possibility of achieving high instrument sensitivity by using selective amplifiers; and 2) the possibility of eliminating the effect of KFP irradiation from external sources operating at a frequency of a commercial system on operation of the device.

Figure 7 explains the operation of the KFP in the sine-wave modulation mode. The photosensitive surface of the KFP is illuminated by a modulated flow with amplitude of $E_o + E_m$. An electric signal at the output of the photodetector $U_o + U_m$ will repeat the shape of the light signal if the work is carried out on the linear section of the light characteristic.

Conversion to sine-wave modulation requires changes in the schematic solution of the control block. A sample block diagram which accomplishes this principle is presented in Figure 8. The KFP and the preamplifier circuit remains unchanged. The comparison circuits also remain unchanged, but unlike the pulsed variant, selective amplifiers IU are now connected in front of them. We have the following sine-wave voltage at the output of the comparison circuit: $U_{vykh} = K\ (A \sin X - B \sin X) = K(A - B) \sin X$, where A and B are conditional signal amplitudes at the input of the comparison circuit and K is the amplification factor of the comparison circuit. If the ratios of A and B vary, for example, $B > A$, $U_{vykh} = -K(A - B) \sin X = K(A - B) \sin (X + \pi)$.

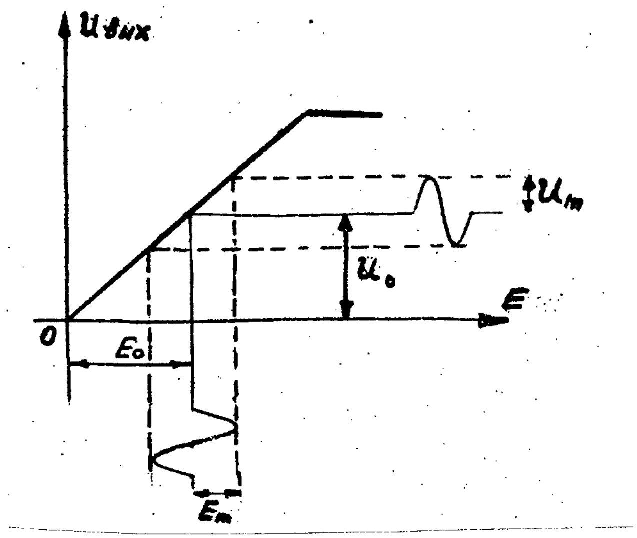


Figure 7. Obtaining Modulated Voltage at the Output of the Photo-detector With Sine-Wave Modulation

This denotes variation of the output voltage phase by π. Conversion of the output signals to control signals is simplified in this case. The sine-wave signal from the output of the comparison circuit is converted to a square-wave signal in the limiting amplifier UO. The synchronization signal is also subject to similar conversion. The NOT inverter to obtain pulses shifted by π is also connected here. Coincidence circuits SS1 and SS2 change the direction of rotation of the motor shaft by reversible shaper RF as a function of the output signal phase. $U_{vykh} = 0$ at $A \simeq B$. The motor is switched off in this case.

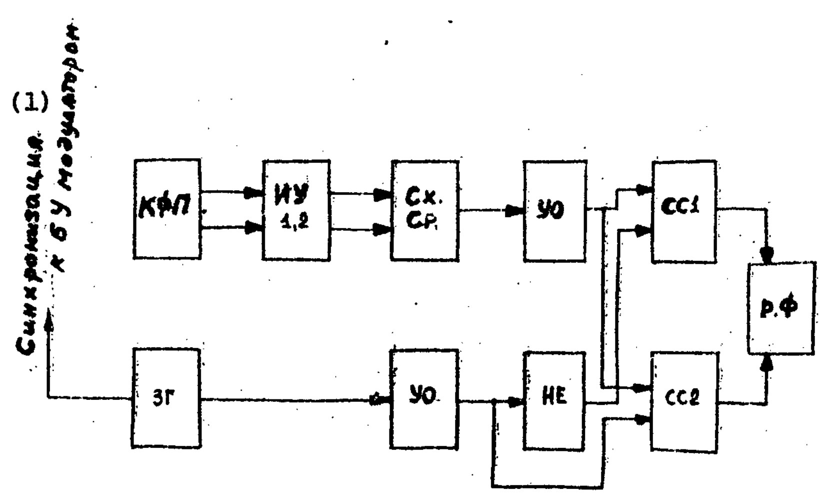


Figure 8. Block Diagram of Instruction Block With Sine-Wave Modulation of Optical Radiation

KEY: 1. Synchronization to BU by modulator

With regard to selecting the type of motor in the automatic adjusting subassemblies of the optical elements, the DC motor may be compared here, for example, to a step motor. A number of characteristic features of step motors makes them very attractive for use in adjusting ASU. These characteristics include, for example, the possibility of using step drives in the systems with digital programmed control and also the possibility of providing rigid fixation of the rotor after the motor stops. The overall dimensions of the ShDA-2fk step motor with nominal torque of 60 gcm comprise 60 x 40 mm, while those of the DPM-30-N-02 DC motor with torque of 100 gcm comprise 45 x 30 mm, i.e., the overall dimensions of the step motor exceed those of the DC motor 1.5 times. With regard to the dimensions of the reduction gear with reducing the motor revolutions to the same speed, the overall dimensions of the DC motors are not less than those of the step motors with regard to the reduction gear.

Schematic and block diagrams for controlling three step motors in an adjusting ASU are presented in Figures 9 and 10. The ShDA-2fk motor has four windings. The most efficient method of controlling the step motor, from the viewpoint of achieving the greatest torque and providing dynamic stability, is the method of paired connection of its windings. Pulses from the instruction block enter the input of the reversible counter. The counter operates in the add or subtract mode depending on the required direction of rotor rotation, which is accomplished by transmitting input pulses to one or another bus (see the block diagram). Thus, one step of the rotor (if there is an unbalance signal from the KFP) corresponds to each light pulse of an adjusted laser with joint operation of the instruction block and the power supply circuit ShD. All the counter flip-flops must be set to the initial position prior to the beginning of work.

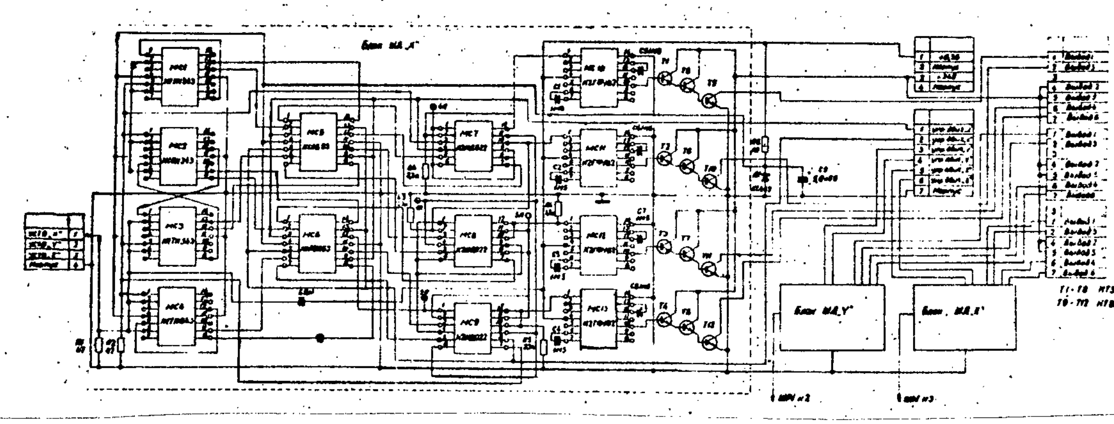


Figure 9. Schematic Diagram of Step Motor Control Block. The explanations are in the text

The required combination of pulses is formed by the reversible counter (MS1-MS4 circuits) and the coincidence circuit (MS5-MS6). Circuits MS10-MS13 form pulses with length of 5 msec which are amplified by transistors T_1-T_{12}.

A pulse distributor is assembled on MS7-MS9 diode assemblies to achieve a four-cycle operating mode of the motor and to protect it against false triggering. Design-wise, the circuit can be made in the form of a standard, Kamakovskiy module of single width.

4. Diagram of Automatic Adjustment of the Laser Cavity Mirrors

Based on the layout of automatic mirror adjustment considered above, a more complex diagram of automatic laser cavity adjustment (the driving oscillator in a powerful laser installation) can be constructed. Angular detuning of the oscillator cavity is possible during operation of the installation due to the following destabilizing factors: mechanical low-frequency and high-frequency oscillations of the optical base of the laser and of the optical elements located in it, thermal drifts of the mechanical attachments and supports with temperature fluctuations of the mechanical elements and so on. The problem of automatic adjustment is to maintain the direction of the optical axis of the cavity with high accuracy ($\simeq 10^{-5}$ rad, see [3]) and at the same time to maintain the direction of the laser beam given by the optical layout of the installation in space. This direction is given by the position of the optical axis of the stabilized optical element in the laser circuit, for example, of the output mirror of the driving oscillator.

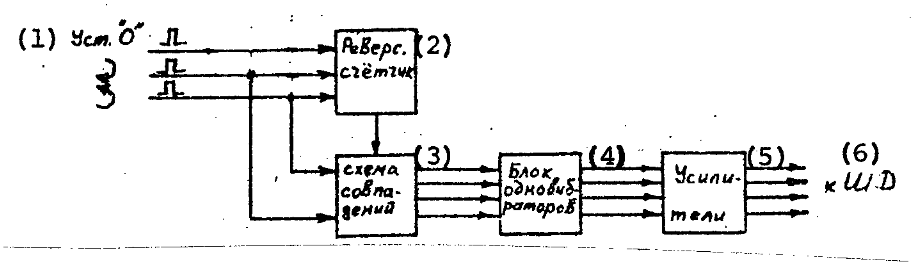


Figure 10. Block Diagram of Instruction Block of Adjusting ASU for Operation With Step Motors

KEY:

1. "0" setting
2. Reversible counter
3. Coincidence circuit
4. Monovibrator block
5. Amplifiers
6. to step motors

A diagram of automatic adjustment of a driving oscillator on neodymium glass for the powerful "Del'fin" laser installation [1, 2] is presented in Figure 11. The oscillator is assembled by the layout of a single-mode laser with Q-factor modulation by a Kerr cell. The adjusting laser beam in this circuit is tied to the direction of the optical axis of the output mirrir (axial mode selector) (1) installed in a thermostabilized mounting. The center of the coordinate photodetector is installed on this optical axis and at the same time the selected direction is "tied" to the center of the KFP. The position of the optical axis of the "opaque" mirror 2 should be installed and maintained in this same direction by using the ASU.

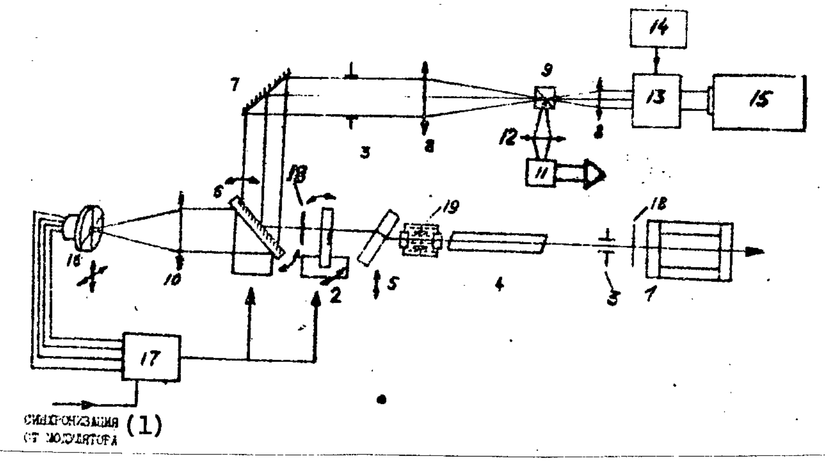


Figure 11. Diagram of Automatic Adjustment of Laser Cavity (Driving Oscillator With Modulated Q-Factor on Neodymium Glass): Notations: 1 -- thermostabilized reference output mirror (axial mode selector); 2 -- "opaque" mirror of cavity with electromechanical drive; 3 -- diaphragms; 4 -- active element; 5 -- movable planoparallel plate; 6 -- partially transparent mirror with electromechanical drive; 7 -- "opaque" mirror; 8 -- collimator objective and eyepiece; 9 -- light-separating cube; 10 -- objective in front of coordinate photodetector; 11 -- remote camera; 12 -- objective of remote camera; 13 -- electro-optical shutter; 14 -- modulator; 15 -- adjusting laser; 16 -- coordinate photodetector; 17 -- instruction block; 18 -- "jumping" diagrams; 19 -- Kerr shutter

KEY: 1. Synchronization from modulator

The beam of a single-mode adjusting laser 15 (for example, a laser based on a YAG:Nd^{3+} crystal operating in the continuous mode) passes through the electrooptical shutter 13, which permits modulation of the laser radiation (for example, by sinusoidal law). The control voltage is transmitted to the modulator from oscillator 14. The laser beam is then expanded by a telescope consisting of two lenses and the central part is cut out of it with approximately uniform cross-sectional intensity distribution. This radiation is also used for adjustment. The adjusting beam is reflected from the "opaque" mirror 7 (with reflection coefficient R 100 percent) and the partially transparent mirror 6 (with reflection coefficient R 96 percent) and passes through the unfilled part of the "opaque" mirror 2, and is brought into the optical axis of the cavity by using plate 5 which shifts the direction of propagation of the adjusting beam to parallel.

The process of adjusting the cavity and maintaining the given direction of generation proceeds as follows. The reflection from the fixed reference mirror 1 is initially brought in to the plane of the KFP (16) manually or from the remote control console by mirror 6 in two coordinates. The adjusting

radiation is focused in this case by a lens 10, forming a circle of specific diameter on the plane of the KFP. The energy center of the adjusting spot and the center of the KFP are joined, for example, by the method described above by using the micrometric slides of the KFP. It should be noted that diaphragm 3, which limits the aperture (and consequently the angular divergence) of the adjusting beam, should be brought out from the cavity to increase the angular resolution when setting the adjusting beam to the given direction. Reflection of the adjusting beam from mirror 2 should also initially be brought out from the KFP. The adjusting ASU of mirror 6, which maintains the direction of the adjusting beam in the given direction of the optical axis of mirror 1, is switched on after the operation of setting the adjusting beam.

By closing reflection from mirror 1 by the "jumping" diaphragm 18, we introduce reflection from the second mirror 2 into the survey zone of the automatic adjusting system (the zone near the center of the coordinate photodetector). The remaining error (misadjustment) of mirror 2 is completed when the ASU is switched on. The cavity of the driving oscillator may then be regarded as adjusted in the given direction. The diaphragm (3) is then automatically introduced to the initial position to the cavity and the auxillary planoparallel transverse plate (5) is brought out. A blind -- the "jumping" diaphragm -- is then introduced between mirrors 6 and 2 to protect the optical elements of the adjusting circuit against penetration of laser radiation in the case of an accident (for example, damage to the reflective coating). Adjustment may be monitored visually on the screen of the visual monitoring device, a signal to which is generated, for example, from the television camera tube on a vidicon (11).

In conclusion the authors express deep gratitude to N. G. Basov and O. N. Krokhin for interest in the given paper and support of it.

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ANNOTATION

The principles of constructing local automatic control systems (ASU) for adjusting the optical elements in a laser installation, the block diagram and the technical possibilities of realizing individual components of ASU and also the working principle and order of functioning of an effective model of an automatic laser mirror adjustment subassembly, which provides precision of aiming the laser beam in a given direction not worse than 1", are considered. Schematic solutions of adjusting the driving oscillator cavity in the powerful "Del'Fin" laser installation are presented.

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CSO: 8144/0117A

FORCED UNDULATORY RADIATION OF RELATIVISTIC ELECTRONS AND PHYSICAL PROCESSES ON AN 'ELECTRON' LASER

Moscow VYNUZHDENNOYE ONDULYATORNOYE IZLUCHENIYE RELYATIVISTSKIKH ELEKTRONOV I FIZICHESKIYE PROTSESSY V "ELEKTRONNOM LAZERE" in Russian 1977 signed to press 11 Jul 77 preprint No 127 pp 1-23

[Preprint of article by A. A. Kolomenskiy and A. N. Lebedev, USSR Academy of Sciences Order of Lenin Physics Institute imeni P. N. Lebedev]

[Text] Annotation

Amplification and generation of coherent radiation in the optical band on the basis of the mechanism of forced magneto-bremsstrahlung (undulatory) radiation of relativistic electrons have been theoretically investigated. Expressions for amplification factor and efficiency have been obtained. It has been demonstrated that radiation reaction plays a substantial role in nonlinear saturation mode and in multiple beam utilization mode. Physically possible variants of electron laser parameters for various spectral intervals and an approximate aggregate of infrared band unit parameters are indicated.

Introduction

As a rule transitions between quantum system discrete spectrum states are utilized for amplification and generation of optical band coherent radiation. In addition, analogous effects are also possible on the basis of transition between states of the continuous spectrum characteristic of macroscopic systems with electron beams. Smallness of generated wavelength in comparison with the characteristic dimensions of the radiating system is achieved with relativistic effects (we know, for example, that spontaneous synchrotron radiation in a relativistic case is shifted into the region of very short wavelengths down to soft X-rays). Such systems can somewhat arbitrarily be called electron lasers. Their operation is based on processes of induced radiation, which can correspond to various radiation mechanisms -- both two-photon, such as Compton scattering on a beam of free electrons with wavelength change, and single-photon, utilizing, for example, magneto-bremsstrahlung (synchrotron, undulatory) radiation or Cherenkov radiation during periodic structure transit.

Attention was drawn to the basic possibility of interaction of the first type long before the appearance of lasers, in [1], which examined scattering of electrons on a standing light wave. This idea found contemporary development in the proposal and design of a "Compton" laser [2]. Single-photon processes of magneto-bremsstrahlung form the basis of cyclotron resonance masers [3] and centimeter-band devices, of the so-called ubitron type [4]. As regards the optical band, only quite recently has experimental research begun on amplification and generation of waves in the infrared region during passage of a relativistic electron beam through an undulator [5, 6, 10].

The aim of this study, which was conducted in 1976, is investigation of the physical peculiarities and potential capabilities of the mechanisms of induced magneto-bremsstrahlung, in particular in the optical and shorter wavebands. Some of the advantages of electron beam systems are straightforwardly clear, such as the deep frexible frequency tuning (determined by electron energy) and the basic possibility of obtaining high absolute outputs. Also quite attractive at first glance are arrangements with a circulating electron beam, which yields part of its energy for radiation in individual orbit segments and making up these losses in other segments, similar to the manner in which this is practiced in circular-orbit accelerators and electron storage rings. As will be evident below, the central question here is the role of reaction of induced radiation to a beam, diminishing its "working" properties and determining the system's maximum possible amplification and efficiency.

We shall examine the problem from two standpoints: on the basis of a concept of "photon gas" kinetics, which stresses the link with the laser radiation mechanism, and on the basis of purely classic concepts, which show the common features of the electron laser with devices of the shf band and which make it possible to elucidate in graphic form the fundamental limitations of the system's capabilities.

For generation of waves of the desired optical band, two principal demands are imposed on the systems -- the presence of spontaneous radiation in the shortwave region and securement of positive feedback, leading to exponential growth of the coherent radiation field at the selected frequency. As was mentioned, the former is achieved because of the relativistic Doppler effect: if an electron with relativistic factor $\gamma = (1-\beta^2)^{-1/2}$ passes along a system with spatial period l, its acceleration changes with frequency $\beta c/l$ in a laboratory system and with frequency $\beta\gamma c/l$ equal to radiation frequency in an attendant system (where an electron is assumed nonrelativistic). For radiation directed at small angle θ to electron velocity, an inverse Larentz transformation gives in the laboratory system frequency

$$\omega \simeq \frac{2\gamma^2 c}{l}(1-\gamma^2\theta^2) \simeq 2\gamma^2 c/l, \qquad \text{(I)}$$

corresponding to the light waveband with entirely macroscopic period $l \sim 1$ cm and moderate energies, from the standpoint of accelerators, of

~ 50 Mev $(\gamma \simeq 10^2)$.

We shall note that shortwave radiation is concentrated in a narrow cone with an angle $\sim \gamma^{-1}$ around the direction of electron instantaneous velocity.

The second of the mentioned requirements can be qualitatively formulated as follows: the probability of spontaneous radiation at the selected frequency should drop with an energy increase, for precisely due to this relationship the process of induced radiation can prevail over induced absorption (see Section 2). In other words, the spectrum of spontaneous radiation should be a line spectrum with line position determined by electron energy. Precisely such a condition is satisfied by motion along a periodic trajectory, whereby the dependence on energy is secured by the Doppler effect (1). In an actual case, when the number of periods N is finite, the spectrum will be quasi-line with relative line width $\sim N^{-1}$. Since the amplification factor should grow with an increase in steepness of the line slope, we shall subsequently in all cases assume $N \gg 1$.

1. Spontaneous Radiation Spectrum

The form and intensity of the spectral line for the general case of quasi-periodic electron trajectory can be directly obtained from the known spectral decomposition of retarded vector-potential [7]. For the Fourier vorticity electric field component we have

$$\vec{E}_\omega = -\frac{ie\omega}{2\pi c^2}\int_{-\infty}^{\infty}\frac{\vec{v}(t)}{R(t)}\exp[i\omega t - ikR(t)]dt, \qquad (2)$$

where $k=\omega/c$, and R -- distance from electron to point of observation. Selecting axis z with unit vector $\vec{n}$ in the direction of radiation, we shall change over to z as integration variable, representing electron velocity in the form

$$\vec{v} = \frac{dz}{dt}(\vec{n} + d\vec{\rho}/dz), \qquad (3)$$

where $\vec{\rho}(z)$ -- vector of lateral deflection from axis z, which by assumption is a periodic function with a period l. Since acceleration is provided only by magnetic field, and radiation reaction is not considered here, electron energy γ remains constant, so that

$$\frac{dz}{dt}\frac{1}{c} = \frac{\sqrt{\gamma^2-1}}{\gamma\sqrt{1+(d\vec{\rho}/dz)^2}} \simeq 1 - \frac{1}{2\gamma^2}[1+\gamma^2(d\vec{\rho}/dz)^2], \qquad (4)$$

where longitudinal movement is assumed relativistic $(\gamma \gg 1)$, and lateral -- nonrelativistic $((d\vec{\rho}/dz)^2 \ll 1)$. Disregarding as usual the weak dependence R (t) in the denominator (2), we have for the radiation field

$$\vec{E}_\omega = -\frac{ie\omega}{2\pi Rc^2}\int_0^{Nl}\frac{d\vec{\rho}}{dz}\exp\left\{\frac{ik}{2\gamma^2}\int[1+\gamma^2(d\vec{\rho}/dz)^2]dz\right\}dz \qquad (5)$$

Due to the periodicity of lateral deflection $\vec{\rho}(z)$ the exponent in (5) periodically oscillates around systematically changing value $ik\sigma z/2\gamma^2$, where

$$\sigma = 1+\gamma^2\overline{(d\vec{\rho}/dz)^2}, \qquad (6)$$

while the line signifies an averaging for the period, and the physical reason for the difference of σ from 1 consists in the fact that with the specified energy, longitudinal velocity decreases somewhat due to the presence of lateral motion (see (4)). Therefore the relationship between wavelength $\lambda = 2\pi/k$, system period 1 and energy γ changes somewhat in comparison with estimating formula (1). It is evident from expression (5) that the radiation field will be maximum realization of relation

$$\gamma^2 = \gamma_r^2 = \sigma l/2\lambda, \qquad (7)$$

which for the reasons specified in Section 2 can be called resonance. With a slight deviation from it

$$\delta = \frac{\gamma - \gamma_r}{\gamma_r} \lesssim N^{-1/2} \qquad (8)$$

integral (5) is easily computed and gives

$$\vec{E}_\omega = \frac{el\vec{a}}{4\pi kc\lambda\delta}\left(e^{-4\pi iN\delta} - 1\right), \qquad (9)$$

where

$$\vec{a} = \overline{\left\{\frac{d\vec{\rho}}{dz}\cdot exp\left[\frac{ik}{2}\int\left((d\vec{\rho}/dz)^2 - \overline{(d\vec{\rho}/dz)^2}\right)dz - 2\pi iz/l\right]\right\}};$$

$$|\vec{a}|^2 = \frac{\lambda}{l}\,\frac{\sigma-1}{\sigma}\,f(\sigma), \qquad (10)$$

while function $f(\sigma)$ depends on the specific type of magnetic system.

With the aid of (9) one can also easily compute the spectral density of the energy radiated per unit of solid angle during system passage by one electron:

$$\mathcal{E}_\omega = ck^2|\vec{E}_\omega|^2 = \frac{e^2l^2|\vec{a}|^2}{4\pi^2c\lambda^2\delta^2}\sin 2\pi N\delta \qquad (11)$$

As could be expected, this quantity, viewed as a function of electron energy, has a sharp mzximum at $\gamma = \gamma_r$ with a relative width $\sim N^{-1}$. Lesser maxima of a diffraction character when

$$\bar{\delta} = s/4N \;\; (s = 1, 2, \ldots;\; s \ll N^{1/2})$$

are connected with the finite length of the radiation region.

From qualitative considerations it is not difficult to picture the order of magnitude of allowances for system parameters whereby the line character of

the spectrum is not substantially disrupted. Expression (11) was obtained for radiation along average velocity. At the same time it is evident from qualitative formula (1) that with an increase in angle the spectrum shifts by relative magnitude $\sim\gamma^2\theta^2$. In order not to go beyond line limits ($\sim N^{-1}$), the angular deviation of trajectory from the calculated periodic should consequently not exceed $\gamma^{-1}N^{-1/2}$, and naturally beam energy scatter should be less than N^{-1}. There is a similar order of allowance for relative magnitude of low-frequency (with period > 1) harmonics of lateral deviation.

As a conclusion to this section, we shall give expressions σ and $f(\sigma)$ for some concrete magnetic systems. In the case of a flat (one-dimensional) magnetic field changing harmonically along z from $-B_\perp$ to $B_\perp$,

$$\sigma = 1 + \frac{1}{8\pi^2}\left(\frac{eB_\perp l}{mc^2}\right)^2; \quad f(\sigma) \simeq \left[J_0\left(\frac{\sigma-1}{\sigma}\right) - J_1\left(\frac{\sigma-1}{\sigma}\right)\right]^2 \tag{12}$$

Radiation is polarized thereby in a plane perpendicular to the magnetic field. For a field with helical symmetry, possessing constant-magnitude rotating lateral component B_1 and homogeneous longitudinal component $B_\parallel$, the trajectory comprises a spiral with a constant radius and pitch, and

$$\sigma = 1 + \frac{(eB_\perp l/2\pi mc^2)^2}{(1-|e|B_\parallel l/2\pi mc^2\gamma)^2}; \quad f(\sigma) \equiv 1. \tag{13}$$

Naturally a wave is radiated thereby which is circularly polarized (see [6]). Field $B_1 \neq 0$, $B_\parallel = 0$ can be created on the axis of two spiral conductors (with opposed currents), possessing pitch 1 and shifted by 1/2. In the absence of lateral magnetic field ($B_1 = 0$) that is, in homogeneous longitudinal field $B_\parallel$, the period of the spiral trajectory is determined by zero of the denominator in (13). This variant, also characteristic of which is a Doppler shift of radiated wave $\lambda = (1-\beta_\parallel)l$, corresponds to so-called autoresonance, examined by the authors in [8]. Rather large magnetic fields are required for its realization in the light waveband.

2. Amplification Factor

We shall examine kinetic relations for processes of induced radiation and absorption. Let $P(\gamma, \vec{k})$ be spontaneous probability of radiation of photon $\vec{k}$ as a result of system passage by one electron with energy γ. Since it is equal to the probability of absorption of an identical photon with an energy increase from $\gamma - \hbar\omega/mc^2$ to γ, the relation for the number of photons in interaction space $n(\vec{k}, t)$, per field oscillator has the form

$$\frac{\partial n}{\partial t} = \int P(\gamma, \vec{k})\left[Q(1+n) - Q(\gamma - \hbar\omega/mc^2)\cdot n\right]d\gamma \tag{14}$$

where $Q(\gamma)$ -- number of electrons passing through the interaction space per unit of time. Considering the small photon energy $\hbar\omega$, one can expand into a series "population" $Q(\gamma - \hbar\omega/mc^2)$, restricting oneself to the first term. Then for a relative increase in the number of photons during time of passage of a system with length Nl we obtain the expression

$$G(t') = -\frac{\hbar\omega N l}{mc^3} \cdot \int d\gamma \cdot Q(\gamma) \frac{\partial}{\partial\gamma} \mathcal{P}(\gamma, t') \qquad (15)$$

It remains to link probability P with the spectral density of spontaneous radiation calculated above. Utilizing a known expression for the number of natural oscillations occurring in frequency interval $d\omega$ and solid angle interval (see [7]), we have

$$\mathcal{P}(\gamma, t') = \frac{8\pi^3 c^3}{\hbar\omega^3 N l S} \mathcal{E}_\omega, \qquad (16)$$

where S -- beam cross section. Physically it is clear that the amplification factor will be maximal for a wave vector directed along the beam axis (with an accuracy of $\sim\gamma^{-1}N^{-1/2}$). Then utilizing expression (11) for a monochromatic beam of electrons with current I, we have

$$G = 2\pi N^2 |\vec{\alpha}|^2 \frac{I}{I_A} \cdot \frac{l^2}{S} \cdot \frac{\partial}{\partial\gamma} \left[\sin\frac{\mu}{2} \Big/ \frac{\mu}{2}\right]^2; \quad \mu = 4\pi N\delta, \qquad (17)$$

where $I_A = mc^3/e \simeq 17$ kA -- (al'venovskiy) current. It is evident from this that the amplification factor will indeed be positive on the right slope of the line, whereby it reaches a maximum at

$$\mu \approx 2.6 \text{ or } \quad \gamma = \gamma_p (1 + 1{,}3/2\pi N). \qquad (18)$$

As a result

$$G_{max} = 0{,}54 \cdot (2\pi)^2 \sqrt{2} \cdot N^3 \frac{I}{I_A} \cdot \frac{l^{1/2} \lambda^{3/2}}{S} \cdot \frac{\sigma - 1}{\sigma^{3/2}} \cdot f(\sigma) \qquad (19)$$

where $f(\sigma)$ depends on the shape of the trajectory (see (12), (13)), whereby f=1 for a helical field.*

The above semi-qualitative conclusion describes the linear stage of the process, since it does not take into account attendant electron phase change relative to the wave and its energy. These processes, however, play a fundamental role not only in nonlinear saturation of the amplification factor but also in change in beam state following radiating system passage. It is precisely the character and degree of this change which determines the possibility of repeated beam utilization for radiation following

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* For this particular case [5, 6] describe an extremely cumbersome calculation of factor G within the framework of traditional quantum-mechanics formalism. The approach we have employed, physically more adequate to the problem, makes it possible to avoid this formalism and leads much more rapidly and graphically to the goal, even in the general case of a periodic field. With accuracy to a factor $\sigma^{3/2}$ obtained in [5, 6], the expression for G_{max} coincides with our formula (19), if it is applied to the case of a helical field.

compensation of that relatively small energy which electrons lose during one-time passage.

Electric field transverse wave $\vec{E}\cdot\exp[iwt-ikz]$, propagating along the z axis, performs per unit of time above the electron work

$$w = Re\left\{e\vec{E}\frac{d\vec{\rho}}{dz}\cdot\frac{dz}{dt}\cdot\exp[i(\omega t-kz)]\right\} = Re\left\{ce\frac{d\vec{\rho}}{dz}\vec{E}\cdot\exp\left[i\frac{k}{2\gamma^2}\int[1+\gamma^2(d\vec{\rho}/dz)^2]dz\right]\right\}, \tag{20}$$

which on the average differs from zero only in the case of resonance (7), (8), when

$$\bar{w} = Re\{ec\vec{E}\vec{a}\} = ec|\vec{E}\vec{a}|\sin\psi \tag{21}$$

Consequently "detuning" δ changes in conformity with equation

$$\frac{d\delta}{dz} = \bar{w}/mc^3\gamma_p = g\sin\psi \; ; \quad g = e|\vec{E}\vec{a}|/mc^2\gamma_p \tag{22}$$

while phase variable $\psi=kz+2\pi z/l-\omega t+\text{const}$ as

$$\frac{d\psi}{dz} = -\frac{k\sigma}{2\gamma^2}+\frac{2\pi}{l} = \frac{4\pi}{l}\delta \tag{23}$$

We shall note that equations (22), (23) are shortened [9], that is, describe systematic energy and phase changes in the assumption that in one period of the system these changes are small ($gl \ll 1$).

If the field level in the system or its length are small, detuning changes little in the process of interaction and is close its initial value δ_i, which also corresponds to the above-examined linear stage of the process. Considering $gl \ll \delta_i^2 \sim N^{-2}$, we obtain by the method of sequential approximations the detuning value at system exit (that is, when z=Nl)

$$\frac{\delta}{\delta_i} = 1-(gl/4\pi\delta_i^2)[\cos(\psi_i+\mu)-\cos\psi_i] - (gl/4\pi\delta_i^2)^2\left[\frac{1}{2}\sin^2(\psi_i+\mu)\sin^2\psi_i+1-\cos\mu-\mu\cos\psi_i\sin(\psi_i+\mu)\right], \tag{24}$$

where now $\mu=4\pi N\delta_i$ (see (17)). In order to determine total field work on the beam, we shall average the obtained expression for the initial phase ψ_i, assuming that distribution of particles is uniform. Then

$$\left\langle\frac{\delta-\delta_i}{\delta_i}\right\rangle = -(gl/4\pi\delta_i^2)^2\left[1-\cos\mu-\frac{1}{2}\mu\sin\mu\right] \tag{25}$$

We shall note that in the first order for $gl/4\pi\delta_i^2$ average energy increase is equal to zero, since the energy increments of particles in positive and negative phases mutually compensate one another. A difference effect, proportional to g^2, arises due to phasing of particles in the region of decelarating phases (if $\delta_i > 0$), which provides the induced radiation effect.

The above is explained in Figure 1, where initial and final particle distribution on the phase plane (δ, ψ) (upper curve) is portrayed. It is not difficult to show that radiation power is optimized with a value $\mu \simeq 2.6$, which fully corresponds to the above obtained condition of maximum steepness of the spontaneous radiation line (18). Writing down an expression for increase in Poynting vector flux as a result of passage of I/e electrons per unit of time through cross section S

$$G\,\frac{S|\vec{E}|^{2}c}{8\pi} = -\frac{mc^{2}I}{e}\langle \delta - \delta_{1} \rangle \gamma_{p} \qquad (26)$$

we obtain an expression for amplification factor G in one passage, precisely coinciding with (19), if vector $\vec{E}$ is parallel to vector $\vec{a}$, that is, for a plane-polarized wave in the case of a flat trajectory and for circular polarized for a spiral trajectory. Equations (22) and (23), however, retaining information on distribution of electrons on the phase plane, also enable one to find nonlinear saturation of amplification factor and maximum system electron efficiency. In addition, description of system operation in terms of resonance interaction of electrons with a traveling wave underscores its community with shf band devices, the closest analog from which in the case of induced undulatory radiation is the ubitron [4].

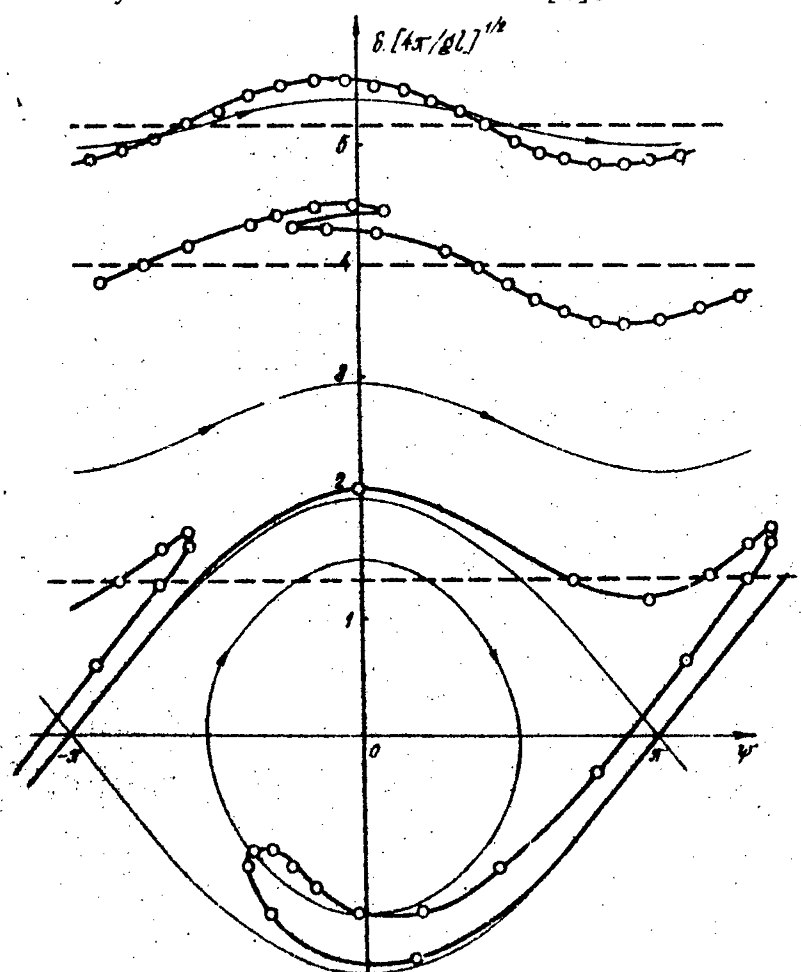

Figure 1 Phase Plane Distribution of Particles Initially Equidistantly positioned along the dashed straight line. The upper two curves correspond to linear mode (μ =2.6), and the lower curve -- to optimized saturation mode (μ =5.4).

3. Saturation Mode and Electron Efficiency

Within the framework of linear theory one can only qualitatively estimate the maximum possible level of generated power, determined by inverse wave action on electrons (we are not examining here other causes of restriction of power, of a technical character, for example, although in certain cases they may be the principal causes). One can expect that nonlinear effects will come into force with a field level where during one passage the energy of at least some electrons will change by an amount in the order of line width, that is, when

$$gl/4\pi\delta_i \sim N^{-1}, \text{ or } gl \sim N^{-2} \tag{27}$$

We shall note that examination of phase plane beam evolution leads to the same criterion: when (27) is satisfied, electrons begin to be wave-captured (see the lower curve in Figure 1), which leads to nonlinear saturation and subsequent breakdown phenomena. It is not difficult to see that electron efficiency, defined as the portion of energy given up in radiation during one passage, is then limited by a quantity in the order of N^{-1}. Naturally determination of the maximum possible efficiency and power level attainable in the system is of interest.

In linear mode far from saturation, as follows from (25), efficiency increases linearly with power P

$$\eta = eGP/Imc^2\gamma_p \qquad (\eta \ll N^{-1}) \tag{28}$$

With a further increase in P, quantity η passes through maximum value

$$\eta_{max} = \varkappa(\mu)/N \tag{29}$$

with "optimal" power

$$P_{опт} = \frac{P_A \cdot S}{4N^4\lambda^2} \cdot \frac{\sigma^2}{(\sigma-1)f(\sigma)} \, r(\mu), \tag{30}$$

where $P_A=m^2c^5/e^2=8.7$ Gw. The behavior of functions $\varkappa(\mu)$ and $r(\mu)$, obtained by numerical solution of equations (22) and (23), is shown in Figure 2 together with slope steepness of spontaneous radiation line (11), proportional to the amplification factor in linear mode. We shall note that for realization of maximum efficiency in steady state, power

$$P_{изл} = \frac{mc^2}{e}\gamma_p I\eta_{max}, \tag{31}$$

characterizing its full quality factor, should be removed from the system. It is easy to see that the conditions of maximization of amplification factor G and efficiency, that is, quantities of removed power, are generally speaking contradictory and require a fine retuning of beam energy. If quantity μ =2.6 to obtain maximum G, that is, the working point should be selected at midpoint on the right slope of the line, then to remove maximum power from the beam, the energy of its particles in the process of radiation should pass the entire slope, beginning with value μ =5.4, whereby $\varkappa(\mu)$ =0.45. All other conditions being equal, such a tuning sharply decreases amplification factor G (see Figure 2).

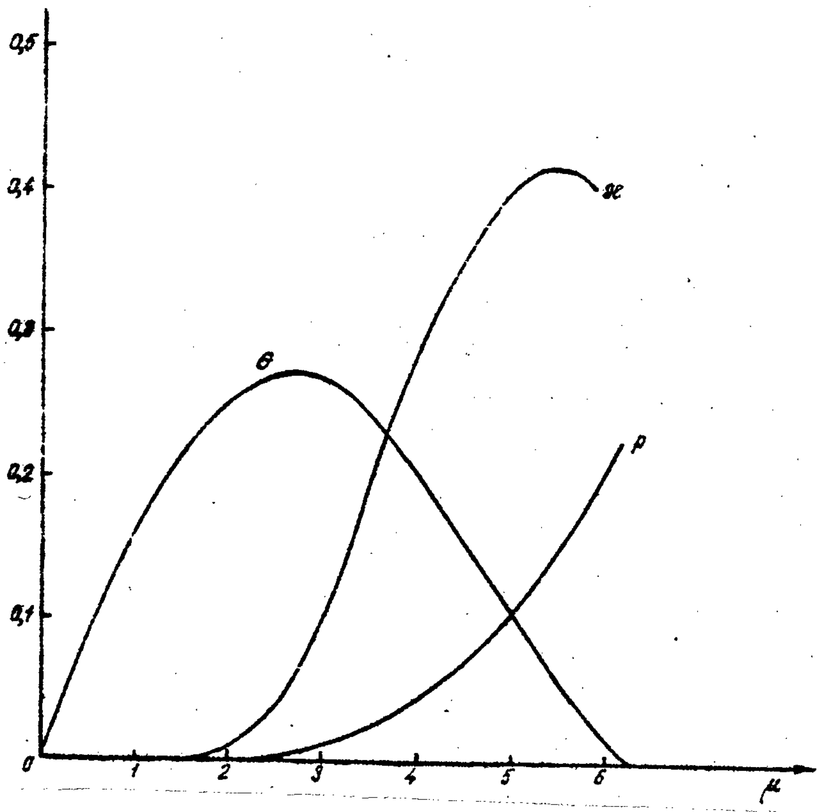

Figure 2.

The smallness of electron efficiency ($\eta \sim N^{-1}$) is more or less a common property of the systems being examined, for in one passage an electron can radiate only energy comparable with line width. Therefore there arises the endeavor to recuperate in some way the relatively large amount of energy stored in the relativistic electron beam. In principle there are two approaches to this problem. The first consists in the efficient taking of energy of "spent" electrons by the electric field, that is, in creating a unique charged particle "decelerator." Due to the excessively large electron energy (in the order of tens of MeV and more), such a system can hardly be electrostatic and should evidently constitute an inverted variant of a resonance linear accelerator.

A second approach, which seems more natural, consists in multiple utilization of one and the same beam circulating in a magnetic system of the storage ring type. Losses to induced undulatory and synchrotron radiation could be effectively compensated with an accelerating system of the same type as in conventional accelerators and storage rings. In connection with the external attractiveness of such an arrangement, we must stress the fundamental

restriction preceding from our examination and lying beyond the framework of simple energy relationships. As is evident from formula (24) and from Figure 1, induced radiation is accompanied not only (and in linear modes not so much) by a decrease in average electron energy but also by the manifestation of energy spread and longitudinal beam density modulation. In contrast to average losses, this effect increases not quadratically but linearly with the radiation field, that is, much faster. Root-mean-square spread introduced by one passage is equal to (see (24))

$$\left\langle \left(\frac{\delta-\delta_i}{\delta_i}\right)^2 \right\rangle = 2\cdot(4\pi g l N^2)^2 \sin^2\frac{\mu}{2}/\mu^4; \quad g l N^2 \ll 1 \tag{32}$$

The spatial scale of corresponding phase plane beam distortions is of the order of emitted wavelength λ, so that on a macroscopic scale the process can be viewed as diffusion of particles along the axis of energies with coefficient (32) for one passage.* Therefore the maximum number of cycles during which diffusion of energy does not yet exceed specificd allowance $\Delta\gamma \sim \gamma/N$, will be equal in order of magnitude

$$n_{max} \simeq 1/N^2 \langle (\delta-\delta_i)^2 \rangle, \tag{33}$$

and the corresponding efficiency

$$\eta_M \simeq n_{max} \langle \delta - \delta_i \rangle = \varkappa_M(\mu)/N; \tag{34}$$

$$\varkappa_M(\mu) = 2\pi\left[\frac{2}{\mu} - ctg\frac{\mu}{2}\right]. \tag{35}$$

Formally multicycle efficiency η_M can, according (29) and (30), substantially exceed η_{max} (for one passage), since $\varkappa_M(\mu) \to \infty$ when $\mu \to 2\pi$. However, Transition into a mode with $\varkappa_M(\mu) \gg 1$ presupposes precise adjustment of electron energy γ in the process of radiation and beam circulation. In addition, amplification factor G inevitably drops off. Therefore rigorous calculation of multicycle mode must be performed for specific installations, which is beyond the scope of this article. We shall merely note that at least in the nonlinear region, utilization of multicycle mode is hardly expedient, since the energy spread introduced by radiation has thereby the same order of magnitude as average losses.

Conclusion

The study we conducted shows the physics of the processes taking place in electron lasers and makes it possible to estimate their basic capabilities. We can point to two principal advantages of such devices. First of all,

* Alongside increase in effective beam phase volume corresponding to longitudinal motion (connected with energy γ), induced radiation also leads to increased emittance, that is, phase volume corresponding to transverse motion. The rates of growth of these phase volumes, that is, rates of diffusion in phase space, are approximately the same.

they simplify the task of creating inverse population, since a beam of relativistic electrons constitutes a system with such a population. Secondly there is the possibility of profound flexible retuning of the frequency of powerful generated coherent radiation, which can be achieved by changing the electron energy (or magnetic field values in the undulator). With an attempt to move toward shorter wavelengths (optical, ultraviolet, X-ray regions), serious problems arise, which as a rule require a compromise approach to selection of such basic parameters as amplification factor and electron efficiency. This is characterized by the figures contained in Table 1, which apply to radiation in three different spectral intervals: λ=5 microns, λ=0.5 microns, λ=0.05 microns. The values of the obtained parameters, which we have employed only for illustration, indicate that if we take for an amplification factor value $G \simeq 1\%$, one can also obtain electron efficiency values in the order of $\eta_{max} \simeq 1\%$. We shall mte that full installation efficiency thereby will be at least several times less than electron efficiency. Quantity η_{max} could be increased by reducing the number of periods ($\eta \sim N^{-1}$), but amplification factor $G \sim N^3$ drops off sharply thereby. In order to maintain G at the previous level, it would be necessary substantially to increase density of electron current ($I \sim N^{-3}$). The necessity of having very high density electron beams is in general one of the principal obstacles in building an electron laser. Under certain conditions, which require increased accuracy of parameter adjustment, quantity η can be raised by employing a circulating electron beam (multicycle mode) with compensation of losses to induced radiation and damping of oscillations excited by this radiation.

Table 1. Some Electron Laser Parameter Variants

(1) Длина волны λ (мкм)	5		0,5		0,05	
(2) Период системы l (см)	3		1,0		0,3	
(3) Магнитное поле $B_\perp$ (кГс)	5		10		10	
(4) Энергия γ	95		140		180	
(5) Коэффициент усиления (%) G	1	10	1	10	1	10
(6) Число периодов системы N	100	300	100	300	100	300
(7) Плотность тока (А/ом^2) I/S	7,7	2,1	$4,7.10^{2}$	$1,3.10^{2}$	$1,3.10^{5}$	$3,5.10^{4}$
(8) Электронный КПД (%) η_{max} (μ = 5,4)	0,45	0,15	0,45	0,15	0,45	0,15
(9) Плотность потока мощности $P_{ген}/S$ (МВт/см^2)	5,9	$4,8.10^{-2}$	$5,3.10^{2}$	4,2	$1,9.10^{5}$	$1,5.10^{3}$
(10) Плотность снимаемой мощности (МВт/см^2) $P_{изл}/S$	1,7	$1,5.10^{-2}$	$1,5.10^{2}$	1,3	$5,4.10^{4}$	$4,9.10^{2}$

Key to Table 1 on preceding page:

1.	Wavelength	6.	Number of system periods
2.	System period (cm)	7.	Current density
3.	Magnetic field (kg)	8.	Electron efficiency
4.	Energy	9.	Flux density, power (Mw/cm^2)
5.	Amplification factor	10.	Density of removed power

Our examination of the physical processes in an electron laser provides a basis for conducting further elaboration with the objective of selection and optimization of technically acceptable parameters. Table 2 gives some idea of their approximate aggregate.

Table 2. Approximate System of Infrared Band Electron Laser Parameters

Undulator	
Retuning band	1-10 microns
Field configuration	Transverse, rotating
Strength	5 kg
Structure period	3 cm
Aperture	1 x 1 cm
Number of periods	100
System length	3 m
Band amplification factor	5-15%
Pulse radiation energy	140-40 J
Pulse power	45-15 kw
Pulse duration	0.3 microsecond
Frequency of repetition	10-0.3 Hz
Chamber aperture	1 cm
Electron Beam	
Electron energy in band	150-50 Mev
Circulating current	1 A
Beam emittance	0.05-0.5 cm.mrad
Cross section	0.02-0.2 cm^2
Energy spread	10^{-3}
Full number of particles	5.10^{11}
Injection energy	15 Mev
Injection current	50 mA
Number of storage cycles	5.10^3
Cooling time	15-500 ms
Compensating System	
Type	Dual-gap, nonretunable resonator
Frequency	3,000 mHz

Table 2 (cont'd)

Losses	
on synchrotron radiation	100-1 ev/cycle
on induced radiation	45-15 kev/cycle
Accelerating voltage	
in radiation pulse	200-50 kv
in interval	1 kv
Power	
in pulse	100 kw
average	1 kw

Magnetic System

Type	Racetrack with division of functions
Period structure	QOQQOQM
Betatron frequencies	3.3
Magnet field index	0.5
Gap length	2 x 4 m
Radius of curvature in magnet	50 cm
Field strength in orbit	10-3 kg
Frequency of field change in storage mode	10 Hz
Magnet aperture	5 x 5 cm
Vacuum	10^{-8} Torr

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SCIENTISTS AND SCIENTIFIC ORGANIZATIONS

STATE PRIZES FOR SCIENCE AND TECHNOLOGY ANNOUNCED

Moscow PRAVDA in Russian 6 Nov 77 p 1, 3

[Announcement by USSR Central Committee and Soviet Council of Ministers: "On the Awarding of USSR State Prizes for 1977 for Science and Technology]

[Text] The Central Committee of the CPSU and the USSR Council of Ministers, having examined the statement presented by the USSR Council of Ministers Committee for Lenin and USSR State Prizes in Science and Technology, decree that the following persons are to be awarded the USSR State Prizes for 1977:

I. Awards in Science

1. Cherenkov, Pavel Alekseyevich, academician, laboratory head, Varfolomeyev, Aleksandr Timofeyevich, Taran, Gennadiy Grigor'yevich, Fetisov, Vladimir Nikolayevich, candidates of physico-mathematical sciences, junior scientific associates, Gorbunov, Andrey Nikolayevich, doctor of physico-mathematical sciences, section head, associates of the USSR Academy of Schiences Physics Institute imeni P. N. Lebedev, Vatset, Petr Ivanovich, doctor of physico-mathematical sciences, laboratory chief of the Ukrainian SSR Academy of Sciences Physico-Technical Institute, Voloshchuk, Viktor Iosifovich, candidate of physico-mathematical sciences, senior scientific associate of the same institute, Khokhlov, Yuriy Kuz'mich, candidate of physico-mathematical sciences, junior scientific associate of the USSR Academy of Sciences Institute of Nuclear Research, Gerasimov, Sergo Borisovich, candidate of physico-mathematical sciences, senior scientific associate of the Joint Institute of Nuclear Research, Dzhibuti, Revaz Il'yich, doctor of physico-mathematical sciences, senior scientific associate of the Georgian SSR Academy of Sciences Physics Institute, Kopaleishvili, Teymuraz Isakovich, doctor of physico-mathematical sciences, chair head at the Tbilisi State University--for the

cycle of works on the research on light nuclear cleavage by high energy gamma rays in Wilson Chambers, acting in strong beams of electron accelerators.

2. Mandel'shtam, Sergey Leonidovich, doctor of physico-mathematical sciences, director of the USSR Academy of Sciences Institute of Spectroscopy, project leader, Zhitkin, Igor' Aleksandrovich, candidate of physico-mathematical sciences, Shurygin, Anatoliy Ivanovich, candidate of technical sciences, senior scientific associates at the USSR Academy of Sciences Physics Institute imeni P. N. Lebedev, Tindo, Igor' Pavlovich, candidate of physico-mathematical sciences, Vasil'yev, Boris Nikolayevich, junior scientific associates of the same institute, Goganov, Dmitriy Alekseyevich, candidate of technical sciences, section head at the Leningrad Scientific-Industrial Association "Burevestnik,"--for the cycle of works on solar X-ray irradiation.

3. Besov, Oleg Vladimirovich, doctor of physico-mathematical sciences, senior scientific associate, Nikol'skiy, Sergey Mikhaylovich, academician, section head, associates at the USSR Academy of Sciences Mathematics Institute imeni V. A. Steklov, Il'yin, Valentin Petrovich, doctor of physico-mathematical sciences, laboratory head of the Leningrad Division of the same institute,--for the monograph "Integral'nyye Predstavleniya Funkstii i Teoremy Vlozheniya" (Integral Representations of Functions and the Embedding Theory), published in 1975.

4. Glushkov, Viktor Mikhaylovich, academician, director of the Ukrainian SSR Academy of Sciences Institute of Cybernetics, project leader, Derkach, Vitaliy Pavlovich, doctor of technical sciences, section head, Kapitonova, Yuliya Vladimirovna, candidate of physico-mathematical sciences, deputy section head, associates of the same institute,--for the cycle of works on the theory of discreet transformers and methods for automating computer design which has found application in operating systems.

5. Minachev, Khabib Minachevich, corresponding member of the USSR Academy of Sciences, deputy director of the USSR Academy of Sciences Institute of Organic Chemistry imeni N. D. Zelinskiy, project leader, Garanin, Vadim Ivanovich, Isakov, Yakov Il'yich, candidates of chemical sciences, senior scientific associates of the same institute,--for the cycle of works on the scientific fundamentals for creating new zeolite catalysts.

6. Buchachenko, Anatoliy Leonidovich, Likhtenshteyn, Gerts Il'yich, Rozantsev, Eduard Grigor'yevich, doctors of chemical sciences, laboratory heads at the USSR Academy of Sciences Institute of Chemical Physics, Neyman, Moisey Borisovich, doctor of chemical

sciences,--for creating a new class of stable organic radicals and their application in chemistry and molecular biology.

7. Sergeyev, Yevgeniy Mikhaylovich, corresponding member of the USSR Academy of Sciences, chair head at the Moscow State University imeni M. V. Lomonosov, project leader, Gerasimova, Antonina Sergeyevna, Yershova, Sof'ya Borisovna, candidates of geological-mineralogical sciences, senior scientific associates, Trofimov, Viktor Titovich, candidate of geological-mineralogical sciences, dotsent, associates of the same university, Baulin, Vladimir Viktorovich, candidate of geological-mineralogical sciences, section head at the Production and Scientific-Research Institute for Engineering Research in Construction, Zakharov, Yuriy Filippovich, candidate of geological-mineralogical sciences, head of the Tyumen section of the same institute, Mel'nikov, Yevgeniy Sergeyevich, candidate of geological-mineralogical sciences, laboratory supervisor at the All-Union Scientific-Research Institute of Hydrogeology and Engineering Geology, Antonenko, Konstantin Ivanovich, chief of the Second Hydrogeological Administration of the USSR Ministry of Geology, Krasninskaya, Antonina Maksimovna, chief geologist of the Hydrogeological Expedition of the Fifteenth Region, Sargina, Irina Mikhaylovna, party chief of the same expedition, Chapovskiy, Yevgeniy Grigor'yevich, senior hydrogeologist of the Pirogov Party of the Hydrogeological Expedition No. 30, and workers of the same administration,--for the cycle of works and special maps for engineering geology which assured the effective national economic development of Western Siberia.

8. Kort, Vladimir Grigor'yevich, doctor of geographical sciences, laboratory head, project leader, Vinogradov, Mikhail Yevgen'yevich, doctor of biological sciences, deputy director, Bezrukov, Panteleymon Leonidovich, corresponding member of the USSR Academy of Sciences, Rass, Teodor Saulovich, doctor of biological sciences, section head, Burkov, Valentin Alekseyevich, doctor of geographical sciences, senior scientific associate, Lisitsyn, Aleksandr Petrovich, corresponding member of the USSR Academy of Sciences, section head, Parin Nikolay Vasil'yevich, doctor of biological sciences, Samoylenko, Vladimir Semenovich, doctor of geographical sciences, laboratory heads, associates of the USSR Academy of Sciences Institute of Oceanology imeni P. P. Shirshov, Dobrovol'skiy, Aleksandr Dmitriyevich, doctor of geographical sciences, chair head at the Moscow State University imeni M. V. Lomonosov, Udintsev, Gleb Borisovich, doctor of geographical sciences, laboratory head at the USSR Academy of Sciences Institute of Terrestrial Physics imeni O. Yu. Shmidt, Bruyevich, Semen Vladimirovich, doctor of chemical sciences,--for the monograph "Tikhiy Okean" (The Pacific Ocean) in ten volumes, published in 1966-1974.

9. Kudryashov, Boris Aleksandrovich, doctor of biological sciences, chair head at the Moscow State University imeni M. V. Lomonosov,--for the monograph "Biologicheskiye Problemy Regulyatsii Zhidkogo Sostoyaniya Krovi i Yeye Svertyvaniya" (Biological Problems in the Regulation of the Fluid State of Blood and Its Coagulation), published in 1975.

10. Knorozov, Yuriy Valentinovich, doctor of historical sciences, senior scientific associate at the Leningrad Division of the USSR Academy of Sciences Institute of Ethnography imeni N. N. Miklukho-Maklay,--for the cycle of works "Issledovaniya Pis'mennosti Maya" (Research on Maya Scripture (Deciphering and Translation)), published in 1955-1975.

11. Alekseyev, Sergey Sergeyevich, doctor of juridical sciences, chair head at the Sverdlovsk Juridical Institute,--for the cycle of works on problems of Marxist-Leninist legal theory, published in 1966-1975.

12. Inozemtsev, Nikolay Nikolayevich, academician, director, Martynov, Vladlen Arkad'yevich, doctor of economics sciences, deputy director, Diligenskiy, German Germanovich, doctor of historical sciences, Nikitin, Sergey Mikhaylovich, doctor of economics sciences, section heads, Mileykovskiy, Abram Gerasimovich, corresponding member of the USSR Academy of Sciences, Kudrov, Valentin Mikhaylovich, Pevzner, Yakov Khatskelevich, Entov, Revol'd Mikhaylovich doctors of economics sciences, section heads, Rymalov, Viktor Vladimirovich, doctor of economics sciences, research leader, associates at the USSR Academy of Sciences Institute of World Economy and International Relations,--for the monograph "Politicheskaya Ekonomiya Sovremennogo Monopolisticheskogo Kapitalizma" (Political Economy of Contemporary Monopolistic Capitalism) in two volumes, published in 1975.

13. Yershov, Vladimir Stepanovich, academician at the VASKhNIL (All-Union Academy of Agricultural Sciences), director of the All-Union Institute of Helminthology imeni K. I. Skryabin, project leader, Bessonov, Andrey Stefanovich, doctor of veterinary sciences, deputy director, Demidov, Nikolay Vasil'yevich, Kuznetsov, Mikhail Ivanovich, Shumakovich, Yevgeniy Yevgen'yevich, doctors of veterinary sciences, Kotel'nikov, Gennadiy Anisimovich, Petrochenko, Vasiliy Ivanovich, doctors of biological sciences, laboratory heads, Tsvetayeva, Nataliya Pavlovna, doctor of veterinary sciences, senior scientific associate, Panasyuk, Dmitriy Iosifovich, doctor of veterinary sciences, section head, associates of the same institute, Velichkin, Petr Andreyevich, doctor of veterinary sciences, department head at the All-Union Agricultural Institute for Correspondence Education, Orlov, Ivan Vasil'yevich, corresponding member of the VASKhNIL,

former chair head at the Moscow Technological Institute of the Meat and Dairy Industry,--for the cycle of works "Biological Foundations for the Prevention of Helminthosis in Agricultural Animals," published in 1962-1975.

14. Chernukh, Aleksey Mikhaylovich, full member at the USSR Academy of Medical Sciences, director of the USSR Academy of Medical Sciences Institute of General Pathology and Pathological Physiology, Kupryanov, Vasiliy Vasil'yevich, full member at the USSR Academy of Medical Sciences, chair head at the Second Moscow State Medical Institute imeni N. I. Pirogov,--for the cycle of works on the study of microcirculation, published in 1961-1975.

II. Awards in Technology

1. Voronenko, Mikhail Stepanovich, general director of the L'vov Industrial Association imeni the 50th Anniversary of October, Zhovchak, Aleksandr Mikhaylovich, machine tool operator brigade leader at the L'vov Motor Plant, Zakharova, Aleksandra Filippovna, chief technologist, Polyakov, Aleksandr Ageyevich, deputy director, Chauskaya, Sonya Il'yinichna, chief engineer, workers at the Tiraspol'sk Sewing Factory imeni the 40th Anniversary of the Komsomol, Kurovskiy, Leonid Frantsevich, shop foreman at the L'vov Synthetic Diamond and Diamond Tool Plant, Marchenko, Ivan Semenovich, candidate of technical sciences, chief engineer of the production association "Kineskop," Petrovskiy, Stepan Ostapovich, general director of the production association "Elektron," Trofimov, Vasiliy Vasil'yevich, chief of the OTK [the Department of Technical Control] at the L'vov Production Association imeni V. I. Lenin, Udovichenko, Yevgeniy Trofimovich, candidate of economics sciences, director of the All-Union Scientific-Research Institute of Meteorology, Measuring and Control Systems, Tsaryuk, Nikolay Maksimovich, technologist-engineer,--for the development of scientific principles of a complex system of production quality control, introduced at enterprises of the L'vovskaya Oblast and the Tirapol'sk Sewing Factory imeni the 40th Anniversary of the Komsomol, which has assured a significant increase in production efficiency and an improvement in product quality.

2. Tarasenko, Timofey Yevdokimovich, senior scientific associate at the Donets Oblast State Agricultural Experimental Station, Prokhozhay, Ivan Dem'yanovich, candidate of agricultural sciences, section head at the same station, Garkavyy, Prokofiy Fomich, academician at the VASKhNIL, section head at the All-Union Breeding and Genetics Institute, Linchevskiy, Anatoliy Adamovich, candidate of agricultural sciences, senior scientific associate at the same institute, Nettevich, Engel' Danilovich,

corresponding member at the VASKhNIL, section head at the Scientific-Research Institute of Agriculture for the Central Regions of the Black Soil Zone, Vinogradova, Nodezhda Mikhaylovna, candidate of agricultural sciences, former senior scientific associate at the same institute,--for the development and industrial introduction of the summer barley types "donetsk-4," "donetsk-6," "nutans-244," "Odessa-36," "Moscow-121."

3. Innos, Endel' Aleksandrovich, general director, Shknevskiy, Emil' Nisonovich, chief engineer, Pustynskiy Fridrikh Izrailevich, chief designer, Merimaa, Kal' Aleksandrovich, excavator operator, workers at the Tallin Production Association "Talleks," Karev, Nikolay Vasil'yevich, section head at the Leningrad Scientific-Production Association of Earth Moving Equipment Construction, Belozerov, Aref Ivanovich, chief engineer of the section at the USSR Ministry of Land Reclamation and Water Management, Kunevichus, Iozas-Al'fredas Iozovich, deputy chief at the Lithuanian Administration for Land Reclamation Construction, Terent'yev, Aleksey Mikhaylovich, deputy chief at the Leningrad Oblast Association for Land Reclamation,--for the creation and development of the series production of highly efficient excavator-lumber stackers and their broad introduction into land reclamation construction in arid lands of the USSR.

4. Ogurtsov, Nikolay Alekseyevich, chief, Mysin, Ivan Polikarpovich, deputy chief, workers at the Main Administration for Water Management Construction and Construction of Sovkhozes in the Krasnodarskiy Kray, Aleshin, Yevgeniy Pavlovich, doctor of biological sciences, chair head at the Kuban Agricultural Institute, Kulish, Aleksandr Danilovich, section supervisor of the teaching-experimental farm "Kuban" of the same institute, Polyakov, Yuriy Nikolayevich, candidate of technical sciences, director, Gol'dner, Ruvim Moyseyevich, chief design engineer, associates of the Kuban State Design and Scientific-Research Institute "Kuban'giprovodkhoz," Kosharnitskiy, Stanislav Alekseyevich, director of the trust "Krasnodargidrostroy," Sarov, Boris Aydamunovich, chief engineer of the Mobile Mechanized Column No. 4 of the same trust, Levin, Petr Andreyevich, chief engineer of the design institute "Giprovodstroy," Prisyazhnyuk, Vasiliy Timofeyevich, deputy chief of the Production Administration for Agriculture of the Krasnodar Kray Ispolkom, Maystrenko, Aleksey Isayevich, director of the experimental-demonstration sovkhoz "Krasnoarmeyskiy" of the same administration,--for the creation of a large water management complex in the Kuban' which has greatly raised the amount of water supply in the river basin and has brought a sharp rise in the production of rice in the Krasnodarskiy Kray.

5. Zatsepin, Sergey Timofeyevich, doctor of medical sciences, supervisor of a section at the Central Scientific-Research Institute of Traumatology and Orthopedic Surgery imeni N. N. Priorov, Imamaliyev, Aydyn Salarovich, doctor of medical sciences, laboratory head at the same institute, Trapeznikov, Nikolay Nikolayevich, corresponding member at the USSR Academy of Medical Sciences, deputy director of the Oncological Scientific Center at the USSR Academy of Medical Sciences, Korzh, Aleksey Aleksandrovich, corresponding member at the USSR Academy of Medical Sciences, director of the Khar'kov Scientific-Research Institute of Orthopedic Surgery and Traumatology imeni Professor M. I. Sitenko, Tkachenko, Sergey Stepanovich, doctor of medical sciences, chair head at the Military-Medical Academy imeni S. M. Kirov, Kovalenko, Petr Petrovich, doctor of medical sciences, chair head at the Rostov State Medical Institute, Dubrov, Yakov Grigor'yevich, doctor of medical sciences, consultant at the Moscow Oblast Scientific-Research Clinical Institute imeni M. F. Vladimirskiy, Chaklin, Vasiliy Dmitriyevich, corresponding member at the USSR Academy of Medical Sciences,--for the experimental substantiation, clinical development and practical introduction of methods for the transplanting of large bone allotransplantates to human beings.

6. Georgiyevskiy, Petr Konstantinovich, deputy minister, project leader, Yefuni, Sergey Naumovich, doctor of medical sciences, section leader at the All-Union Scientific-Research Institute for Clinical and Experimental Surgery, Lukich, Vitaliy Leonidovich, doctor of medical sciences, Giorgobiani, Teymuraz Nikolayevich, candidate of medical sciences, senior scientific associate at the same institute, Glukhov, Semen Arkad'yevich, candidate of technical sciences, senior scientific associate at the All-Union Scientific-Research Institute for the Manufacture of Medical Instruments, Shulika, Valeriy Petrovich, candidate of technical sciences, chief engineer, Lopatin, Vladimir Viktorovich, section chief, Yermolayev, Nikolay Yevgen'yevich, deputy section chief, associates of the State and Union Design Institute, Klimov, Leonid Yakovlevich, deputy chief designer at the machine unit plant "Nauka," Ivanov, Aleksandr Yakovlevich, senior foreman of the SMU-2, Shokhanov, Nikolay Alekseyevich, fitter-repairman brigadier of the MSU-19,--for creating a complex of medical barochambers for hyperbaric oxygenation.

7. Romanov, Vladimir Fedorovich, candidate of technical sciences, director, Ovchinnikov, Anatoliy Alekseyevich, candidate of technical sciences, deputy director, Storchak, Gena Abramovna, candidate of technical sciences, laboratory head, associates at the All-Union Scientific-Research and Design Engineering Institute of Natural Diamonds and Instruments, Fedulayev,

Vitaliy Pavlovich, chief of the All-Union Production Association "Soyuzalmazinstrument," Martirosov, Eduard Bogratovich, deputy chief of the same association, Zhazhuyev, Vladimir Shamilovich, director of the Kabardino-Balkar Plant for Diamond Instruments imeni the Lenin Komsomol, Birman, Zyama Moiseyevich, section chief at the L'vov Plant of Artificial Diamonds and Diamond Instruments, Kalabushkina, Nina Pavlovna, deputy chief technologist at the Leningrad Abrasive Materials Plant "Il'yich," Pongil'skiy, Nikolay Flegontovich, chief project designer at the All-Union Scientific-Research and Survey-Design Institute for Metallurgy Machine Building, Nyun'ko, Oleg Iosifovich, chief designer at the Ryazan' Heavy Forge-Press Equipment Plant, Skidanenko, Anatoliy Ivanovich, deputy chief engineer at the Poltava Plant of Synthethic Diamonds and Diamond Instruments imeni the 50th Anniversary of the USSR,--for creating the mass production of native diamond instruments on the basis of scientific-technological resolutions which assure a high rate of development in the diamond sector and satisfy the needs of the national economy.

8. Grishin, Petr Ivanovich, director, Grishin, Anatoliy Vasil'yevich, chief engineer, Efros, Viktor Valentinovich, candidate of technical sciences, chief designer, Shaanov, Aleksandr Iosifovich, candidate of technical sciences, Yerokhin, Nikolay Georgiyevich, deputies to the chief designer, Igoshin, Viktor Mikhaylovich, chief technologist, Kovylin, Viktor Vasil'yevich, shop foreman, Boltunov, Vladimir Ivanovich, Ruzin, Nikolay Alekseyevich, brigadiers, workers at the Vladimirsk Tractor Plant imeni A. A. Zhdanov, Voytetskiy, Georgiy Panteleymonovich, chief of the All-Union Industrial Association for the Production of Tractor and Combine Engines, Markelov, Nikolay Nikoloyevich, candidate of technical sciences, director of the State and Union Scientific-Research Tractor Institute, Pospelov, Dmitriy Rozumnikovich, candidate of technical sciences, laboratory head at the same institute,--for designing a number of universal air-cooled diesel engines and organizing their specialized flow line-mass production.

9. Vysotskiy, Aleksey Viktorovich, candidate of technical sciences, chief engineer of the Interchangeability Bureau in the Metal-Processing Industry, Kurochkin, Anatoliy Petrovich, candidate of technical sciences, chief designer, Rozentul, Solomon Abramovich, candidate of technical sciences, laboratory head, associates of the same bureau, Shaver, Lazar' Solomonovich, chief designer, Sorochkin, Boris Moiseyevich, candidate of technical sciences, chief deputy designer, workers at the Leningrad Instrument Production Association, Pilippchuk, Vladimir Alekseyevich, chief designer at the Chelyabinsk Instrument Plant, Kleymenov, Yuriy Viktorovich, chief engineer

at the Moscow Instrument Plant "Kalibr," Manuylov, Boris Vasil'yevich, chief of the design office of the same plant, Tyshkovskiy, Semen Mikhaylovich, chief of the TsZL [Central Plant Laboratory] of the First State Ball Bearings Plant, Gorlov, Valentin Vasil'yevich, deputy section chief at the Moscow Motor Plant imeni I. A. Likhachev (Production Association "ZIL"),--for developing the series production of equipment for the automatic control of sizes and introducing that development into the automobile, ball bearings and other sectors of industry.

10. Viktorov, Vladimir Andreyevich, doctor of technical sciences, former laboratory head at the Institute for Problems of Management, project leader, Lukin, Boris Vasil'yevich, candidate of technical sciences, senior scientific associate, Mishenin, Viktor Ivanovich, group head, associates of the same institute, Iordan, Georgiy Genrikhovich, doctor of technical sciences, director of the State Scientific-Research Institute for Thermal-Power Tool Construction, Kurnosov, Nikolay Mikhaylovich, candidate of technical sciences, deputy director of the same institute, Radugin, Sergey Sergeyevich, former director of the Ryazan' Plant "Teplopribor," Kiyashev, Aleksandr Ivanovich, chief designer, Poletayev, Boris Konstantinovich, deputy chief designer, Myasnikov, Aleksandr Grigor'yevich, chief of the SKTB [Special Design and Technological Office], Zakharkin, Yevgeniy Nikolayevich, fitter, workers at the same plant, Mityashin, Igor' Petrovich, candidate of technical sciences, deputy director, Ul'yanov, Anatoliy Stepanovich, candidate of technical sciences, laboratory head, associates at the Scientific-Research and Design-Engineering Institute for Thermal-Power Tool Construction,--for developing the theoretical fundamentals and the invariance principles for the high-frequency radio wave method of measuring non-electrical values, and creating on this basis a complex of high-frequency instruments for controlling engineering parameters, and introducing that method into series production.

11. Stepanenkov, Georgiy Grigor'yevich, candidate of technical sciences, general director, Seliber, Boris Abelivich, candidate of technical sciences, chief designer, project leaders, Tkachenko, Aleksandr Nikolayevich, candidate of technical sciences, section chief, Alekseyev, Yuriy Aleksandrovich, senior design engineer, Mayanskiy, Iosif Isaakovich, laboratory chief of the OKB [Special Design Office], Yakovleva, Lyubov' Vasil'yevna, assembler, workers at the Leningrad Production Association "Vibrator," Ilyunin, Konstantin Konstanovich, candidate of technical sciences, former director of the Krasnodar Plant for Electric Measuring Devices, Yefimenko, Viktor Ivanovich, deputy chief engineer of the SKB of the same plant, Vitkovskiy, Valeriy Georgiyevich,

director of the Omsk Plant of Precision Electrical Instruments, Men'shikova, Vera Grigor'yevna, assembler at the same plant, Orlovskiy, Vladimir Vladimirovich, section chief at the Leningrad Division of the All-Union State Planning Institute "Teploelektroproyekt,"--for creating and developing a complex of analogue signaling contact devices (ASK) and broadly introducing that complex into the control and management of complex scientific and industrial installations.

12. Mal'to, Vladimir Ivanovich, chief engineer, Rakhman, Yakov Aronovich, candidate of technical sciences, Kadomskiy, Igor' Aleksandrovich, Zaytsev, Valentin Andreyevich, section chiefs, Svidel'skiy, Arnol'd Petrovich, laboratory chief, workers at the Design Bureau of Precision Electron Machine Building, Pogotskiy, Eduard Iosifovich, foreman chief at the Instrument Construction Plant, Grammatin, Aleksandr Panteleymonovich, doctor of technical sciences, laboratory chief at the State Optical Institute imeni S. I. Vavilov, Rassudova, Galina Nikolayevna, candidate of physico-mathematical sciences, senior scientific associate of the same institute, Tryakov, Erik Nikolayevich, chief specialist at the Ministry of the Electronics Industry,--for creating a complex of automatic precision optic-mechanical equipment for microelectronics.

13. Bondarenko, Boris Romanovich, candidate of technical sciences, deputy director of the All-Union Scientific-Research, Design-Planning and Technological Institute for Electric Locomotive Construction, Dubina, Igor' Yakovlevich, director, Matusevich, Stanislav Borisovich, chief engineer, Konovalov, Vasiliy Vasil'yevich, brigadier of fitters, workers at the Dnepropetrovsk Electric Locomotive Construction Plant, Kuz'menko, Leonid Aleksandrovich, chief, Bratash, Viktor Aleksandrovich, candidate of technical sciences, chief engineer, associates at the Special Design-Planning and Technological Bureau for Industrial Electric Locomotives of the same plant, Potapov, Mikhail Gennadiyevich, doctor of technical sciences, laboratory chief at the Institute of Mining imeni A. A. Skochinskiy, Ozhigov, Yuriy Sergeyevich, board chief of the Sokolovsko-Sarbay Mining-Concentration Combine imeni V. I. Lenin, Fomin, Aleksandr Prokop'yevich, deputy chief engineer at the Novocherkassk Electric Locomotive Construction Plant, Ishchupanovskiy, Vitaliy Fedorovich, foreman chief at the Lebedinsky Mining-Enrichment Combine, Lyulintsev, Sergey Vasil'yevich, deputy board chief at the USSR Ministry of the Coal Industry, Koruzhem, Aleksey Sergeyevich, candidate of technical sciences, chief board engineer at the USSR Ministry of Ferrous Metallurgy,--for creating and rapidly developing the series production of a standardized number of highly efficient traction machines and the introduction of railroad transportation of open mine products.

14. Kagan, Yakov Mikhaylovich, doctor of technical sciences, director of the State Institute "Giprotyumenneftgaz," project leader, Lukashkin, Yuriy Aleksandrovich, chief engineer, Aleyev, Irshat Shavaleyevich, chief design engineer, Tabakov, Nikolay Viktorovich, candidate of technical sciences, chief section specialist, workers of the same institute, Dongaryan, Shagan Saakovich, deputy chief minister of the petroleum industry, Ilyasov, Boris Fedorovich, director of the trust "Nizhnevartovskdorstroy," Parasyuk, Aleksandr Stepanovich, deputy chief of the Main Tyumen Production Administration for the Gas and Petroleum Industry, Krol, Matvey Markovich, former deputy chief of the same administration, Kuzovatkin, Roman Ivanovich, chief of the petroleum-gas production administration "Nizhnevartovskneft'" imeni V. I. Lenin, Nezhdanov, Nikolay Pavlovich, brigadier of the complex brigade SU-44 of the trust "Samotlorneftepromstroy," Chizhevskiy, Mikhail Vladimirovich, chief engineer of the Main Tyumen Petroleum and Gas Equipment Construction Administration, Chirskov, Vladimir Grigor'yevich, chief of the Main Siberian Pipeline Construction Administration,--for developing and introducing new highly efficient scientific-technical and engineering resolutions for rapidly developing the petroleum gas fields "Samotlor."

15. Gayday, Vladimir Stepanovich, shaft sinker, Yerpylev, Viktor Mikhaylovich, director, Goncharov, Aleksandr Il'yich, chief mechanic, Isakov, Sergey Mikhaylovich, section chief, Mel'nichenko, Leontiy Grigor'yevich, electro-fitter, Men'shikov, Gennadiy Ignat'yevich, mining excavator machine operator, Chernykh, Nikolay Grigor'yevich, chief technologist, workers at the mine "Nagornaya" of the Southern Kuzbass Production Association for Coal Mining, Yevseyev, Vasiliy Sergeyevich, candidate of technical sciences, general director of the same association, Malevich, Nikolay Aleksandrovich, doctor of technical sciences, deputy director, Petukhov, Nikolay Nikalayevich, candidate of technical sciences, section head, Khrunov, Nikolay Ivanovich, chief project designer, associates at the Central Scientific-Research and Planning-Design Institute for Excavator Machines and Complexes for the Coal, Mining Industry and Underground Construction, Teterin, Vladimir Borisovich, director of the Skuratov Experimental Plant of the same institute,--for creating the highly efficient mine-cutting complexes "Kuzbass," which have assured a high level of productivity on the part of mine cutters and rapid rates of preparatory operations.

16. Bogdanov, Aleksandr Petrovich, candidate of technical sciences, former deputy shop foreman of the Zaporozhye Titanium-Magnesium Combine, Yegorov, Anatoliy Pavlovich, candidate of technical sciences, deputy section chief of the same combine, Tatakin, Aleksandr Nikolayevich, candidate of technical sciences,

laboratory head at the All-Union Scientific-Research and Design Institute for the Aluminum, Magnesium and Electrode Industries, Bondarenko, Nikolay Veniaminovich, candidate of technical sciences, senior scientific associate of the same institute, Devyatkin, Vladimir Nikolayevich, candidate of technical sciences, section head at the All-Union Scientific-Research and Design Institute of Titanium, Chalabayev, Il'yas Almabekovich, shop foreman, Dragunkin, Yuriy Nikolayevich, senior electrolysis specialist, workers at the Ust'-Kamenogor Titanium-Magnesium Combine imeni the 50th Anniversary of the October Revolution, Kashkarov, Aleksandr Zakharovich, chief engineer, Shchelkonogov, Anatoliy Afanas'yevich, shop foreman, workers at the Bereznikov Titanium-Magnesium Combine, Karavaynyy, Aleksandr Ivanovich, chief engineer at the Solikam Magnesium plant of the same combine, Kolesnikov, Anatoliy Vladimirovich, section chief at the All-Union Association for the Production of Rare and Alloy Metals, Strelets, Khaim Lipovich, doctor of technical sciences,--for the development and broad industrial introduction of a new highly efficient apparatus and process for producing magnesium.

17. Baguzov, Nikolay Pavlovich, candidate of technical sciences, board chief, Spiridonov, Vladimir Mikhaylovich, deputy section chief, workers at the USSR Gosstroy, Kim, Nikolay Nikolayevich, candidate of architecture, deputy director of the Central Scientific-Research and Design-Experimental Institute of Industrial Buildings and Structures, Kostyukovskiy, Mosey Grigor'yevich, Ostrovskiy, Mendel' Yevseyevich, Ushakov, Nikolay Alekseyevich, candidates of technical sciences, section supervisors, Vasil'yev, Boris Fedorovich, chief section specialist, Vatman, Yakov Petrovich, chief design architect, Kartashov, Konstantin Nikolayevich, candidate of technical sciences, consultant, associates of the same institute, Pavlov, Boris Grigor'yevich, candidate of technical sciences, deputy chief engineer, Shuvalov, Lev Kirillovich, chief section designer, workers at the Central Scientific-Research and Design Institute for Structural Metallo-Designs, Zamarayev, Vasiliy Artem'yevich, structural engineer,--for the development and introduction of a system for standardizing industrial buildings and structures.

18. Gotsiridze, Viktor Davidovich, chief of the Tbilisi Administration for Tunnel Construction, project leader, Dzhakeli, Gayoz Akakiyevich, detachment chief, Mamuliya, Yermolay Ivanovich, district surveyor, Kozhukhov, Yakov Matveyevich, brigadier of a complex brigade, workers of Detachment No. 9 of the same administration, Tsimintiya, Givi Kirillovich, candidate of technical sciences, chief of the Construction-Repair Train No. 213 of the Tbilisi Administration for Tunnel Construction, Rizhinashvili, Rafael' Samsonovich, former chief design engineer

of the State Design Institute "Gruzgiprogorstroy," Goff, Anatoliy Genvikhovich, chief design engineer of the same institute, Tintilozov, Zurab Konstantinovich, doctor of geographical sciences, laboratory head at the Georgian SSR Academy of Sciences Institute of Geography imeni Vakhushti, Kipiani, Shalve Yakint'yevich, candidate of geographical science, senior scientific associate of the same institute, Vouba, Valeriy Sokratovich, director of the Novoafonskaya Cave Complex, Okrodzhanashvili, Arsen Andreyevich, junior scientific associate, Markozashvili, Teymuraz Mikhaylovich, architect-engineer,--for creating for the first time in the USSR a unique Novoafonskaya cave complex.

19. Zatseplin, Aleksandr Tikhonovich, chief designer, Korzhov, Vladimir Nikolayevich, candidate of technical sciences, chief, Kondrashev, Robert Konstantinovich, Smirnov, Petr Dmitriyevich, candidate of technical sciences, bureau chiefs, Koval', Leonid Pavlovich, Sem'yanov, Arkadiy Pavlovich, section chief, workers at the KTB [Design and Technological Office] of the Production-Technological Association of the Fish Industry, Slavinskiy, Nikolay Fedorovich, chief engineer, Tepin, Andrey Ivanovich, brigadier of assembly-fitters, workers of the same association, Mel'nik, Dmitriy Semenovich, assembly-fitter at the Kaliningrad Experimental Mechanic Plant, Pavlov, Yevgeniy Grigor'yevich, board chief at the USSR Ministry of Fisheries, Parshin, Ivan Antonovich, section chief at the same ministry, Piletskiy, Mikhail Matveyevich, former chief engineer at the Baltic Fish Canning Combine,--for the development, series production and industrial introduction of universal complex equipment for fish canning production.

20. Shershnev, Viktor Nilovich, director, Antonyuk-Bogashchenko, Arkadiy Yevlampiyevich, Golikov, Oleg Ivanovich, shop foremen, Ivanov, Valentin Semenovich, brigadier of ship repair and fitters, Demchenko, Oleg Pavlovich, doctor of technical sciences, chief designer for automation facilities, Dem'ynchenko, Viktor Yakovlevich, Freyman, Ruvim Yudovich, deputies to the chief project designer, Gorbunov, Boris Aleksandrovich, Chukrin, Aleksandr Vasil'yevich, chief designers for systems and devices, workers at the Baltic Plant imeni Sergo Ordzhonikidze, Ivanov, Aleksey Nikitich, fitter assembler at the Leningrad Electric Machine Building Association "Elektrosila," Lugovtsov, Nikolay Petrovich, candidate of technical sciences, deputy chief designer at the production association "Kirovskiy Zavod," Danilov, Leonid Grigor'yevich, deputy chief of the Murmansk Marine Navigation Administration,--for building the nuclear ice breaker "Arktika."

III. Textbooks

For Higher Institutions of Learning

1. Mukhim, Konstantin Nikiforovich, doctor of physico-mathematical sciences, professor at the Moscow Engineering-Physics Institute,--for the textbook "Experimental Nuclear Physics" in two volumes, published in 1974 (3d edition).

2. Kaurichev, Ivan Sergeyevich, doctor of agricultural sciences, chair head, project leader, Panov, Nikolay Petrovich, doctor of agriculture sciences, professor, associates at the Moscow Agricultural Academy imeni K. A. Timiryazev, Aleksandrovna, Lyudmila Nikolayevna, doctor of agricultural sciences, chair head at the Leningrad Agricultural Institute, Rozov, Nikolay Nikolayevich, doctor of geographical sciences, senior scientific associate at the Soil Science Institute imeni V. V. Dokuchayev, Grechin, Ivan Pavlovich, Poddubnyy, Nikolay Nikolayevich, doctors of agricultural sciences,--for the textbook "Soil Science," published in 1975 (2d edition).

3. Drushchits, Vladimir Vasil'yevich, doctor of geological-mineralogical sciences, professor at the Moscow State University imeni M. V. Lomonosov,--for the textbook "Paleontology of Invertebrates," published in 1974.

For High Schools

Maksakovskiy, Vladimir Pavlovich, doctor of geographical sciences, chair head, project leader, Rakovskiy, Sergey Nikolayevich, Smidovich, Irina Nikolayevna, Solov'yeva, Margarita Grigor'yevna, candidates of geographical sciences, dotsents, associates at the Moscow State Pedagogical Institute imeni V. I. Lenin, Antem'yeva Aleksandr Grigor'yevna, candidate of geographical sciences, former dotsent at the same institute,--for the ninth grade textbook "Economic Geography of Foreign Countries," published in 1975 (2d edition).

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L. Brezhnev

Chairman of the USSR Council of Ministers
A. Kosygin

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LIST OF AUTHORS FROM 'UPRAVLYAYUSHCHIYE SISTEMY I MASHINY' No 3, 1977

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